Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR.

VOL. XI. NEW YORK, APRIL, 1906. No. 2.

"Compressed Air,"

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR.

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Editorial Announcement.

Commencing with the May issue, COMPRESSED AIR will be published hereafter by The Kobbe Company, New York. The ever increasing uses to which compressed air is being put, and the important place it holds in hundreds of industries to-day have made it imperative that COMPRESSED AIR, for ten years the leading—in fact, the only—periodical devoted exclusively to this subject, be correspondingly enlarged and broadened to keep pace with the progress of pneumatics in general, for which it stands sponsor.

The form of the paper will be changed, in that its size will be 7 by 10 inches, and there will be other radical improvements, so that COMPRESSED AIR, in outward form, will be on a level with the best printed and illustrated magazines now published.

Mr. W. L. Saunders will still remain as Editor-in-Chief. Mr. W. R. Hulbert, M. E., well fitted, both as a theoretical and practical engineer, will be managing editor.

Contributions and correspondence from those interested in the uses and development of compressed air for industrial purposes will be gladly received and made use of if acceptable, and requests for information will be given prompt and courteous attention.

To those of our readers who bind their copies of COMPRESSED AIR, we make the following suggestion: That they include among their copies for the year 1904-1905 the issues of March and April; these latter issues really belong to the year 1905-1906, but as COMPRESSED AIR appears in enlarged form with its issue of May, it might not be expedient to bind them with the larger copies.

The "Air Man's" Point of View.

It is a great mistake in the initial installation of a compressed air plant to provide only for the immediate needs of the establishment. It might be set down as a rule without exception that once air tools are used in a shop, the demand for their services will increase. Unless there is something radically wrong in the construction and operation, they will prove their ability as time and money savers. When it is demonstrated that the first equipment of tools will not supply the demands, additions are bound to come. As a result more air will be needed. If the compressor and the piping system were not originally designed to meet the increased needs it means a distinct loss which, with a little foresight, might have been avoided. An air compressor continually operated with an overload, cannot be economical. The best compressor will meet such demand for a time, but it is going to save money to put in a larger compressor rather than run one constantly above its rated capacity. An insufficient piping system means a reduction in the air pressure, with con-

sequent injury to the effectiveness of the tools in operation.

The day when the installation of a compressed air plant in the factory, machine shop or foundry was an experiment, has passed. If proper attention is given to the selection of the most suitable equipment and its proper installation, there need be no guess-work as to the increase in the demands for that form of power in the future and consequent increase in output of your plant.

In addition to the natural growth of the plant, experience has proven that as soon as the compressor has been installed the air can be used to advantage, and with economy, in a variety of ways which were not considered at first. While none of these may be important enough singly to have made the first installation of such a plant desirable, they are of sufficient importance to make it advantageous to supply the air needed, after once the installation is made. Such uses are likely to develop in the course of time, and failure to care for them will mean a loss of small but valuable economies.

It is a fact that too little attention is given to the installation of a compressed air equipment. When a manufacturer plans his factory, his power plant is a very important consideration. He looks into the subject deeply and considers the merits of engines, boilers and the like, with a view to meeting his own particular conditions. The same care should be taken in the selection of the air compressor, the arrangement of the piping system and the choice of the attendant pneumatic machinery. Too many shop men put the compressor away in a corner, connect it with a few hundred feet of pipe, and trust to willing but inexperienced hands to develop it into an economical part of the shop system. Compressors can be operated by men without experience, and it is by no means essential that a corps of practised operators with pneumatic tools be engaged in their shop. You cannot, however, expect economical results unless there is proper care for the compressor and the devices which utilize the compressed air.

This development of the use of compressed air has brought to the fore a class of skilled mechanics, who for the want of a better title, may be called "air men." Their experience and training has taught them to look after the various details of the compressed air plant, and to get the best out of it that is possible. Their point of view is an interesting one. We are publishing in this issue an article written by one of these men, who has had much experience in this field and whose ideas will be read with interest, not only by his fellow workers, but by the makers of compressed air machinery and the manufacturers who use its machinery.

The "Air Man's" Point of View.

BY THE "AIR MAN."

It may not be uninteresting to look at the pneumatic end of up-to-date manufacturing establishments from the point of view of the air-man, who is more or less in charge of air service and tools and is held responsible for almost every shortcoming; being in many cases the long-suffering victim of circumstances entirely beyond his control.

He is a kind of a buffer between the compressors and the workmen, gets the knocks on both sides; and if not of some capacity, great patience and inexhaustible interest in his work, is quite likely to be put down and out without recourse.

His duties in different establishments in the same line of business probably vary more than those of almost any other position, partly because the managers of the business have no special knowledge of air and its application, and no time to acquire the same, and partly because few men have had opportunities to perfect themselves so as to satisfactorily perform all duties that should be theirs.

The management may add the air-plant to their establishment because competi-

tors have by its use attained results otherwise impossible.

Having decided to install a plant, they select one recommended by their friends, or used by their competitors, or the quickest, or the cheapest attainable; let their piper—who, very likely, never saw an air-plant—plan and install pipe lines for distribution and in a comparatively short time learn that instead of a dozen or so of tools, they could economically use fifty —not to mention the other uses, more or less legitimate, that are always being made of air wherever available—and that both compressor and pipe lines should be double or treble the capacity which was at first deemed ample.

Perhaps they do not at once appoint an air-man, but add the responsibility of running and caring for the compressors to the other duties of the engineer, who has already enough to look after without having to care for a kind of power in which he is totally inexperienced.

The distributing lines are sometimes under the care of the piper, sometimes under the direction of the engineer, and the connections to the tools are everybody's business.

When a pneumatic tool gives out it is sent to the tool room and the first available man is directed to fix it up. As time goes on first one man, then another, will work on air tools until all are expected to be competent in that line with an actual experience of perhaps days, where months would not be too much to make an expert.

Hose; not the especial care of any person will rapidly deteriorate, and it is no uncommon thing for oil to be put into hose to be driven through it to the tool. It should be needless to say that such practice, besides being wasteful, will soon destroy hose, besides sending dirt with the oil through the tools to their serious injury.

Finding at length that air power is expensive, the manager selects from his force a man whom he knows to be faithful and directs him to assume care; sometimes of the tools or hose only, sometimes of tools and hose, sometimes of tools, hose and pipe lines, and sometimes of the whole plant, and so a new air man is born. If he is intelligently efficient, a long stride has been taken, and results that will be appreciated by the management will soon appear.

In a case somewhat similar to the above I was appointed air man on a plant of about 150 miscellaneous tools on ship work. We now have nearly 600. At that time the distribution, with the exception of 1,500 feet of 5-inch main, was all through 2-inch lines varying in length from 300 to 1,300 feet, and as the initial pressure of 100 pounds had sometimes been found to fall below 30 on ships, new compressors had been contracted for.

Having pronounced ideas on the growth of air plants, I suggested at least 6-inch pipe for mains to the water front, and 4-inch distributing mains; was listened to with attention and, I presume, was thought a visionary or crank. At all events, there was no move for improvement till after the new compressors were installed, which did not materially change existing conditions.

The manager, having occasion to visit some establishments of a similar character, returned and allowed everything I had suggested and contracted for more compressors to bring our capacity up to 4,000 feet instead of the 1,500 feet originaly believed to be all that would ever be required. At the same time machine tools were purchased and a small shop placed in my charge for the repairing of hose, pneumatic tools and appliances.

In laying the new mains the same attention was given to inclining the pipes for drainage that would be given to steam, and traps were installed at the low points that automatically eject condensed water and are, in my opinion, preferable to after-coolers, because after-coolers may not reduce the temperature to that of the outer air and may thus allow uncondensed water to pass, while traps placed four or five hundred feet from the compressor are very effective. These traps should be protected from frost and, if continuous freezing weather exists for a week or more, I have made it a practice to heat them once in three or four days to make sure that the passing air—which may be below freezing temperature—shall not form ice in them.

The method of heating traps varies with conditions, but I find good results from placing them so that they can be submerged in hot water that can be drained off when cool. This measure is simply precautionary and I cannot vouch for its necessity.

Some pneumatic tools are provided with air strainers designed to keep grit or

scale from entering the working parts, but many are not, and many more are provided with ostensible strainers that are of no practical value, being so small as to clog quickly, and usually constructed with wire gauze that sooner or later breaks and enters the tools, causing as much damage as they are designed to prevent.

Our method is to lead lines of 1½-inch hose to the vicinity of the work and to connect on the end of this hose manifold outlets mounted on an enlarged chamber across which is stretched a diaphragm of bunting. Bunting makes an efficient and lasting strainer and can be very cheaply maintained.

For fixed shop connections, a different form of manifold is constructed, but it also contains the bunting strainer, which, in most cases, lasts about two years before needing renewal.

Carrying 100 pounds pressure, we can supply 15 miscellaneous tools or 30 scaling hammers from each 1½-inch hose, and if the workmen follow instructions and blow out the small hose before connecting tools, nothing more harmful than rubber will ever enter a tool.

We had a good deal of difficulty in finding the best ¾-inch hose adapted to our work, and have now decided that a marline-woven covered hose is the most satisfactory as well as the most economical in the end, as the marline protects the outside of the hose from the action of the weather, the hose is lighter and more pliable and—if the condition of the hose seems to warrant it—broken places in the covering can be served so as to be nearly equal to new.

Certain specifications have been made regarding our hose that are, I believe, not usual with purchasers, but the hose as now received certainly wears longer than any previous purchases.

We require that marline-woven air hose shall stand a hydrostatic test of 500 pounds and that the covering shall extend from coupling to coupling, as this gives support to the weakest part of the hose, which is that covering the end of the coupling sleeve. It is obvious that coupling clamps must be applied *outside* of the covering, and some hose manufacturers refuse to do this, claiming that clamps cannot be safely applied in this way. But our answer is that we had successfully practised this method for more than a year in our repairs before asking it of the manufacturers, and we have purchased thousands of feet of hose fitted in this manner.

It should be stated that we use a hose clamp of our own design for repairs, that is made in three parts and drawn together by three bolts, which I believe to be preferable to those furnished by any manufacturer. We use nothing but screwed couplings, and by screwing the male thread of the ¾-inch hose into the valve on the manifold and making a special fitting for connecting the leaders—which are 6 or 8 feet of 7-16-inch hose leading from the ¾-inch hose to the tool—to the female end, we reduce the necessary number of joints to the minimum.

We also use leather for all gaskets, and in the purchase of valves select those of such design that when they become leaky the original seat can be replaced with leather.

We have valves perfectly air-tight that were fitted with leather seats more than two years ago and never renewed.

Hydraulic Compressed Air in Connecticut.*

The use of compressed air for the development and transmission of power is very old. On the walls of a tomb in Egypt, there is a representation of two men standing on leather bags of air, alternately pressing them down with their feet, to produce a blast for a furnace. The ancients used compressed air in blow guns, in forming jets for fountains, in blasts for forges, and for other purposes. Papin used compressed air for forwarding packages, in tubes, two hundred years ago in France. It has long been used in diving-bells and in tunneling. Brunel used it in tunneling under the Thames in 1825. In 1849 compression was proposed to be performed in stages, with inter-coolers between each stage, to get 750 pounds pressure for locomotives.

The first successful use of compressed air for the transmission of power, as now known and used, was at the Mt. Cenis tunnel in 1861, where air was compressed to five atmospheres by two methods, one being by pumps or rams in which water was the piston, but though the air came in

*** A paper read by J. Herbert Shedd, Consulting Engineer, Providence, R. I., before the March, 1905, meeting of the New England Water Works Association.**

contact with the water, it was only slightly cooled, at the surface of the water and around the walls of the cylinders.

About 1870, at Vienna, and later in Paris, a system was installed for working and regulating a great number of clocks by the use of compressed air from a central station. This soon developed into an extremely important system of power transmission. Paris now has great compressor plants supplying 25,000 horsepower, and more than 50 miles of distribution pipes, supplying air at 75 pounds pressure to thousands of customers, who use it for every purpose, from cooling beer or dusting furniture, to running electric light dynamos. A little stove, with a common kerosene lamp, is used to heat the air before use in the small motors. The motors in use range in size from one-tenth of a horse-power to 150 horsepower, most of them being less than one horse-power. They are started or stopped by simply opening or closing a valve.

The cooling of the air while it is being compressed, and reheating it for use in engines, are matters of great importance. If the air is cooled as it is being compressed, the volume will be much smaller, under a given pressure, than the same amount of air would occupy if allowed to retain the heat caused by compression. Then again, if the compressed air is heated just as it enters the engine, the volume will be much increased, while the same pressure is maintained. The economy in using coal for developing power in this way is so great that four or five times as much power can be secured from a pound of coal, through reheating the air, as can be secured through making steam. The reason for this is chiefly that a great portion of the heat of the coal is absorbed, and becomes latent and ineffective, in turning water from the fluid to the gaseous form in making steam power, and no such loss occurs in expanding the air and so increasing *its* power. It is feasible to increase the power of an air engine fifty per cent., by such reheating of the air.

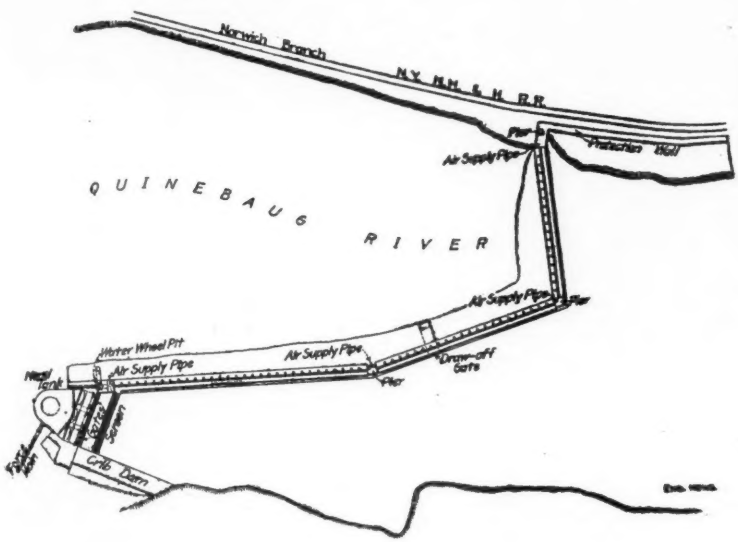


FIG. I.

The method of compressing air by entraining it in water, and causing it to pass down in the water to a great depth, so that it is subjected to a great weight of this incompressible fluid, is an ideal one. In this way the air is compressed isothermally, the heat of compression being ab-

sorbed steadily by the surrounding water, and the air is, therefore, delivered to the pipe line as cool as the water through which it has passed. The compressed air is also drier, or will be when used in the motor, than the atmospheric air from which it was withdrawn. This comes from the fact that the surrounding water absorbs the moisture precipitated from the air as its capacity to hold water is diminished under compression. A dry, cool air is thus secured for the distribution system, comparatively free from the danger of freezing on its way to the motor, or on its expansion in or from the motor. Where there is no moisture to freeze, there is no freezing.

I have been asked to describe to you, briefly, some of the features of a recent installation of a plant for the hydraulic compression of air, to be transmitted a few miles for use in the development of power. This plant is on the Quinebaug River, just above its junction with the Shetucket River in Connecticut, and alongside the track of the Norwich & Worcester Railroad, near the point where the track passes through a tunnel; which fact has given the name of the tunnel privilege to the falls which have been utilized by the establishment of this plant. At this point the river passes through a narrow, rocky gorge, and to utilize the full fall available, the surface of the water above the dam must be brought within a few feet of the level of the track. This condition made necessary the adoption of devices for limiting the height to which flood water would rise over the proposed dam, so as not to overflow the railroad track. For this purpose the length of overflow on the dam was increased, so far as practicable, by laying the plan of the dam somewhat in the form of the letter Z, thus about doubling the length of the overflow of the dam, and of course, correspondingly decreasing the thickness of the sheet of freshet water passing over it. Another device consisted in the establishment of automatic flashboards, so designed that with the water at the normal stage of the river, the flashboards would retain their position and hold the water to the full allowable height, but upon the increase in the discharge of the river, and consequent rise of the surface above the level of the flashboards, they would turn to a nearly horizontal position and so open a passage for the water to a level between three and four feet lower than the top of the flashboards when in their normal positions.

In the plan, Fig. 1, the positions of the screen, gates, and compressor tank are to be seen upon the left bank of the river. The shore and the bed of the river at this point are of ledge, but the bed of the stream had been filled in places to a considerable depth by bowlders unattached, though compactly placed, and it was not considered safe to form the dam upon any other material than the solid ledge in place. Laborious and expensive excavation was necessary in some places to uncover the ledge, and at points excavation was made considerably below the sea level.

To protect the men from inundation by the water in the river, coffer dams were erected, covering successively different portions of the excavation, and these coffer dams were generally formed of square-edged planks, set vertically and supported by timber cribs.

The dam is formed of what is called Cyclopean concrete, consisting of Portland cement mortar with stone, gravel, and sand of varying sizes up to those as heavy as could be handled by the derrick. These materials were so mixed that no two pieces of large size would touch each other, but every piece was surrounded and encased in materials of less size down to the fine powder of the Portland cement. These materials were so placed as to form a dam of the necessary stability, and the form of section for this purpose, as adopted, is shown in Fig. 2.

The materials, while the cement was setting, were held in position by forms of plank set to enclose the dam and removed when the mortar had set sufficiently for that purpose. The positions of some of these enclosing forms, together with the character of materials used, may be seen in Fig. 2.

When the concrete structure had arrived at a sufficient elevation to form the floor of the inlet to the compressor, the surface was carefully leveled and floated and troweled to the right elevation. This was at the lower end of the dam on the left bank of the river.

It was necessary to control the access of water from the river to the head tank of the compressor, and for this purpose substantial mill gates were used. These gates control three openings, eleven feet wide and eleven feet high each. These

gates can be operated by a small water wheel set in the head wall of the dam.

In constructing the dam it was necessary to put it in in sections, so that the river might be diverted and passed through or over one section while another section was being constructed. In making a junction of a new section with one which had been previously built, care was taken to lock the two together as securely as possible to obtain a tight connection and one which would have the greatest available strength. The surface of a section, partially constructed, at one end of an angle in the dam, and where preparations were making to begin the construction of a new section, is shown in Fig. 3.

The flashboards, designed to open and furnish additional opportunity for storm water to escape, are substantial structures, formed of white oak and steel, in sections six feet in length and three feet seven inches in height. Efforts have long been made to construct automatic, or movable dams, which would open when the quantity of water flowing in the river required it, and would, of themselves, close again when the water in the river had returned to a safe level. Nearly seventy years ago a dam was formed of a series of shutters, in France, with the axis so placed that the pressure of water above and below would be equal when the level of water in the pond stood at the top of the flashboards; that is, the axis was one-third the height above the bottom of the flashboards. When the water rose above this point, the pressure became unequal and was greatest above the axis. When the dam opened and relieved the pond, it was found that the dam would not set itself up against the stream, after having once opened, and therefore the automatic action sought for had not been accomplished. In the present instance the flashboards are so hung that they do automatically, and gradually, open and close as the water rises above the crest or falls to a level with it. Some details of these flashboards are shown in Fig. 3, and a view of the top of the dam with

FIG. 2. SHOWING FORMS AND CHARACTER OF CONCRETE.

flashboards wedged in various positions is shown in Fig. 6. When the water in the pond is at its normal level, and the flashboards are in their normal positions, the point of bearing on the axis is at one-third the height of the flashboards above the bottom, or at the centre of the pressure of the water. The lower portion of the flashboard is so weighted that the centre of gravity of the moving parts is below the point of bearing, and upstream from the perpendicular line drawn through the point of bearing. The flashboard is hung on a rolling hanger, confined in place, having such a form that as the height of water against the dam increases and tips the flashboard, the resisting point of the flashboard rises to meet the new centre of pressure and the resultant forces produced by the moving water. In its new position, the resistance of the flashboard to motion, and the forces tending to move it, are in equilibrium so long as there is no change in the volume of water flowing, but as this volume changes, the flashboard assumes a new position, either wider or less open, as the quantity of water continues to increase or decrease. This result arises from a combination of overbalancing weight, in the lower part of the flashboard, aided by an equalization of the areas above and below the point of bearing, on which the forces, caused by the moving water, act when the dam is open. The device is simple and massive. The frames on which the hangers roll and to which they are confined are well anchored to the masonry and are so constructed as to furnish a stop to the flashboard when it is fully open, to prevent the possibility of its passing beyond a point where it could be favorably acted upon, as the level of the water in the river retreats to its normal height. These flashboards have now gone through several winters, with their freshets, accompanied by ice, logs or uprooted trees or other floating matter and have withstood all this without resulting injury, and they have worked satisfactorily in allowing increased

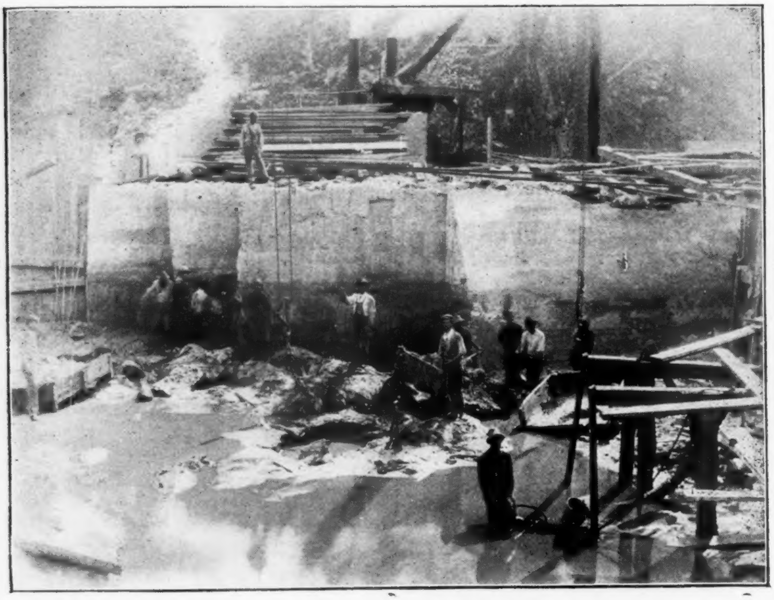


FIG. 3. JUNCTION OF SECTIONS OF THE DAM.

opportunity for the escape of freshet water and in withholding the pond level to its normal height.

Having now brought the water to such an elevation that we can avail of a sufficient fall between its surface and the tail water we will proceed to a further consideration of the Norwich compressor plant with the available fall of 22 feet. In order to compress the air to a sufficient degree by submitting it to the weight of a head of water, a shaft was sunk vertically to a depth 208 feet below the bed of the river or 215 feet below the surface of the tail water, and at the bottom this shaft was enlarged into a chamber to contain the air separator. The shaft is 24 feet in diameter and the chamber at the bottom is 52 feet in diameter. Opening out of the chamber at the bottom is an air reservoir regulator, in the form of a tunnel from 15 to 20 feet in height and 18 feet in width and having a length of about 100 feet. Suspended in

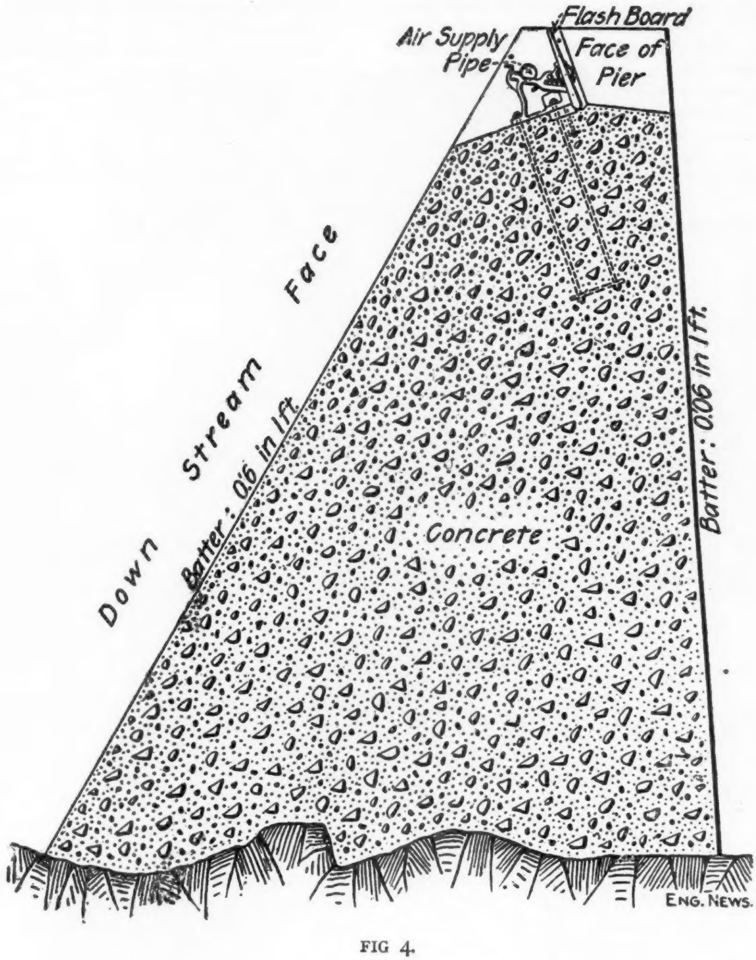


FIG 4.

the middle of the shaft is a downflow pipe of steel, about 14 feet in diameter, connected at the top with the head tank, through which water is received from above the dam, and at the bottom with a separator chamber. This chamber is surmounted by an air reservoir, to contain the compressed air when separated from the water in which it had been entrained, and with which it had been carried to the bottom of the shaft. From the air reservoir over the separator, a 16-inch leading main rises to the surface, and is laid toward Norwich, conveying air under about 90 pounds pressure for the use of the engines at the several establishments employing it for power. A general idea of the shaft, down-flow pipe, separator, leading main, etc., can be obtained from Fig. 8.

In sinking this shaft through the ledge, below the bed of the river, it was found that the upper portion was not sufficiently strong to serve for the permanent walls of the shaft, and for a considerable distance the excavation was lined with concrete, formed by filling a space between curbing, inserted for the purpose, and the surface of the ledge as excavated.

After the shaft and its appurtenances had been completed, the erection of the head tank, downflow pipe, and separator, formed of steel, was proceeded with. During this time, the flow of the river, at whatever stage, was passed over the dam, or through a sluiceway.

Fig. 9 is a view of the head wall, with a portion of the dam, looking diagonally down-stream, during the construction of the separator.

After the steel work had been completed, all the false works and accessories were removed, and water was turned through the apparatus.

When the compressor is in full operation, entraining the air and supplying it to the air chamber and leading main, the collection of air may be more rapid than its withdrawal for use in engines, or for other purposes. To avoid the disturbance which would be likely to occur if the accumulated volume in the air chamber should force the line of separation between the air and water below the bottom of the downflow pipe, and thus allow of an eruption of air through the downflow pipe and head piece, provision is made for a blow-off, or escape of air to the atmosphere, through a blow-off pipe, having an aperture at the bottom higher than the level of the bottom of the downflow pipe, and through this aperture the excess of air supplied to the separator may escape, before the water line in the air reservoir is carried low enough to cause damage. A view of the entire plant, taken while this escape pipe was in operation and blowing off a surplus of air mixed with water, is shown in Plate III, Fig. 2. When this blow-off pipe was first set in position it was turned so as to discharge nearly at right angles across the river, and it was

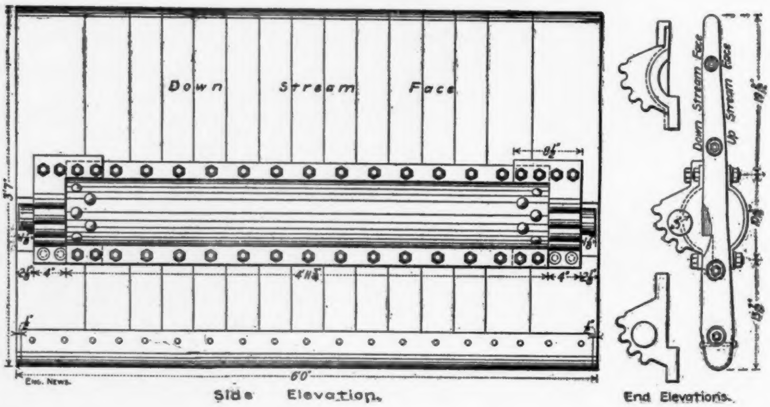


FIG. 5.

found that the air and water sometimes escaped with such force that it would drench a passenger train passing over the track. The direction of the pipe was then changed so as to discharge diagonally down the river, as now represented, and where it could do no harm.

The process of entraining the air to the separator before its passage with water thereby, a sufficient pressure is induced to cause a free flow of the outer air through its proper channels to the water. Having been entrained there, at the ordinary atmospheric pressure, the air is carried down in bubbles with the water, and is steadily compressed as the depth of the water increases until, as in this case, it reaches a pressure of about seven atmos-

FIG. 6. VIEW OF CREST OF DAM, SHOWING AUTOMATIC FLUSHBOARDS.

through the compressor is accomplished by submerging orifices, or air pipes, below or in contact with the surface of the flowing water; such apertures or pipes having proper channels for a free communication with the outer air. The air being in contact with the flowing water is entrained by it, and a partial vacuum being caused pheres. Having escaped from the water by floating out of it as the water passes slowly through the separator, it retains, in the air chamber, the pressure due to the weight of the column of water having the height equal to the difference in level between the tail water escaping from the apparatus and the line of separation in the

air chamber between the accumulated air and the water out of which that air has floated.

The volume of air which can be carried down with water depends somewhat upon the fall, or the difference of level between the pond water and the surface of the tail water. The greater that difference of level, within reasonable limits, the greater the volume of air which can be carried down with water. In this case, apparently the volume of air is about one-third that of the volume of water passing

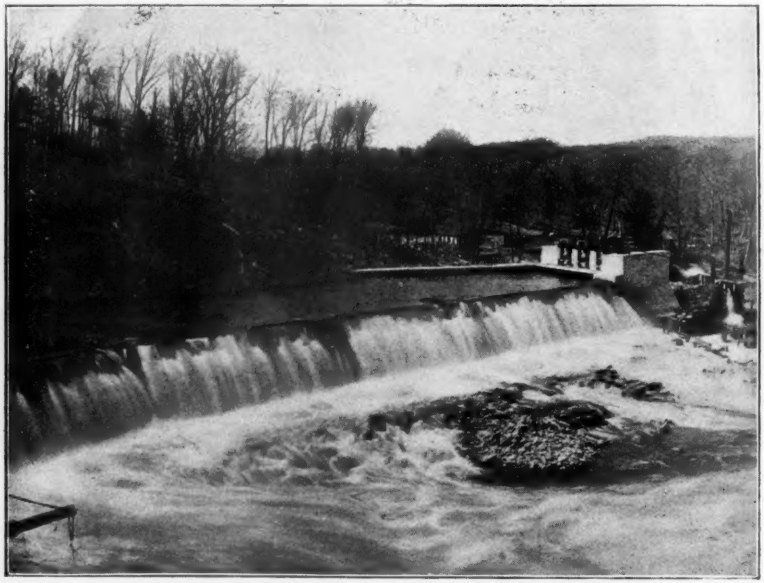
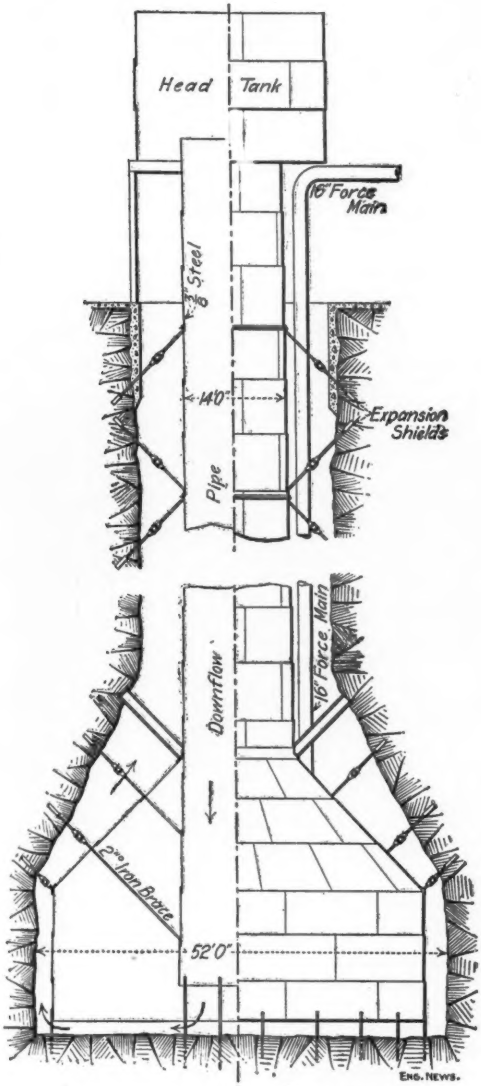


FIG. 7. VISIBLE PORTION OF COMPRESSOR IN ACTION.

through the apparatus. The combined volume, formed of a mixture of air and water, is of course lighter than a column of solid water, and the aërated column cannot be quite so much *longer* than the solid water column as is represented by the amount of the fall, because a certain amount of force, represented by a portion of the fall, is necessary to cause the mixture of air and water to flow through the separator. I know of no experiments bearing directly upon this matter, but it seems probable that a limit of the volume of air which could be entrained and carried down by a surrounding volume of water, would be reached when the aërated column is about fifty feet longer than the solid water column.

There are various means of measuring the amount of air which may be supplied from a given source, the most satisfactory of which probably is to pass it through an air meter, having the usual recording attachment operated by clockwork. Various observations have been made upon the amount of air which would pass through an orifice, shaped approximately like the contracted vein formed when a fluid passes under pressure through an aperture in a thin plate. The volume, or weight, of air in pounds per second, may be ascertained, with reasonable accuracy, by taking the area of a circular orifice of this form, in square inches, and multiplying that by the *absolute* pressure, in pounds per square inch, entering the orifice, divided by the square root of the *absolute* temperature, in degrees Fahrenheit, and the whole multiplied by a coefficient vary-



½ Section. ½ Elevation.

FIG. 8.

ing somewhat with the area of the orifice. For an orifice of one inch diameter the coefficient may be taken at .53.

It is of great importance that the pipes leading the compressed air from the source of supply to the point of use shall be tight, and it is much more difficult to secure such tightness with air than it is with water, or even with steam. Cast iron as a material for such pipes has been very successfully used, but if the joints have been formed in one piece with the pipe, they cannot be successfully made tight by calking with lead, in the manner found to be safe in conveying water.

The joint most extensively used in Paris, and found to be satisfactory there, is formed upon cast-iron pipes having a plain spigot at each end; having brought two pieces of pipe together, place over the joint so formed a short sleeve, nearly fitting the pipe, and long enough to fully cover the joint under such variation of position as may arise in practice. Against each end of this sleeve is placed a rubber ring or gasket, and these rubber rings may be pinched against the ends of the sleeve by other properly formed sleeves or hubs, encircling the pipe and having flanges through which bolts may pass, the hubs being drawn toward each other by nuts on the bolts, thus squeezing the rubber ring between the hub, sleeve, and the pipe. It is necessary to select a kind of rubber well adapted to this service, in order to secure a permanently tight joint, but with materials properly selected and properly applied, the leakage has been found to be so small that it may be neglected in estimating the amount of air which may be delivered from a distribution system.

In cases where it is desired to substitute another form of power in works where steam engines have been used, compressed air has a great advantage over electricity, in the matter of economy. It is not necessary with air, as it is with electricity, to install new motors at the works, but the engines which have been previously used with steam are well adapted for use with compressed air, thus avoiding considerable expense which would be necessary for electric motors.

In Magog, Canada, I inspected the operation of a plant where air had been compressed by water, in a manner similar to that in operation at Norwich, and where a number of engines were running to drive printing presses for printing cloth. I asked the machinist if there was any special trouble in substituting air for steam in an ordinary engine. He took me into the machine shop, where an engine was driving the machines, and operated by steam. A connection had been made to this engine from the air compressor, and two pipes, one leading steam and one leading compressed air to the engine cylinder, lay side by side. The machinist took hold of the steam valve with one hand, and the air valve with the other hand, and gradually closed the steam valve and opened the air valve, until the engine was running entirely with compressed air instead of with steam. After running a few minutes in this way he reversed the process, gradually closing the air valve and opening the steam valve, until the machinery was being again driven entirely by steam power. Both operations were performed without any apparent change in the running of the lathes and planers, or other machinery, and it is probable that no machinist in the shop knew that any change in the power had been made. The only disturbance during the entire operation, that I noticed, was a slight sound of thumping in the engine, when the air was shut off and the steam re-introduced, probably caused by the condensation of a small amount of steam when passing into the cylinder, which had been cooled by the compressed air. Any non-condensing steam engine seems to be well adapted to driving by compressed air, whether used at full stroke or under cut-off, the substitution of air for steam being made without changing the engine.

I have before mentioned that a great economy in the use of compressed air for power purposes may be secured by reheating the air just as it enters the engine. An economy of from 30 to 40 per cent. is sometimes possible in this way.

Compressed air has a great advantage, when it is desired to use transmitted power intermittently, and with periods of non-use intervening with periods of use. There is no loss in maintaining this power when it is not in use. There is no leakage like the leakage of electricity. There is no reduction of pressure like that caused by the condensation of steam. The whole power is available whether used continuously or at intervals.

Mr. Sickman—Under what conditions would that be obtained? When you are using a great quantity or a small quantity?

Mr. Shedd—It is when using the quantity to which the compressor is adapted. I believe the local engineer has said he thought he could obtain somewhere near eighty per cent., but we have never, to my knowledge, accurately measured the efficiency at this point. The velocity of the water when it is entraining the air seems to be about eight feet per second when it is doing its best work, and under those conditions the efficiency, as I say, in the experiments in which I took part, was a little over seventy per cent.

air is drawn in and goes down in bubbles with the water. At Norwich the headpiece is a sort of gridiron with each bar hollow, open on the lower side and supplied with air at the ends, and the water passing down between these gridiron-like bars, the air passes horizontally through the bars into the water as it passes by. There is a plate nearly across the pipe, you might almost call it a pipe, a gridiron bar with a quarter-inch aperture on each side. The headpiece is under three or four feet of water all the time and the

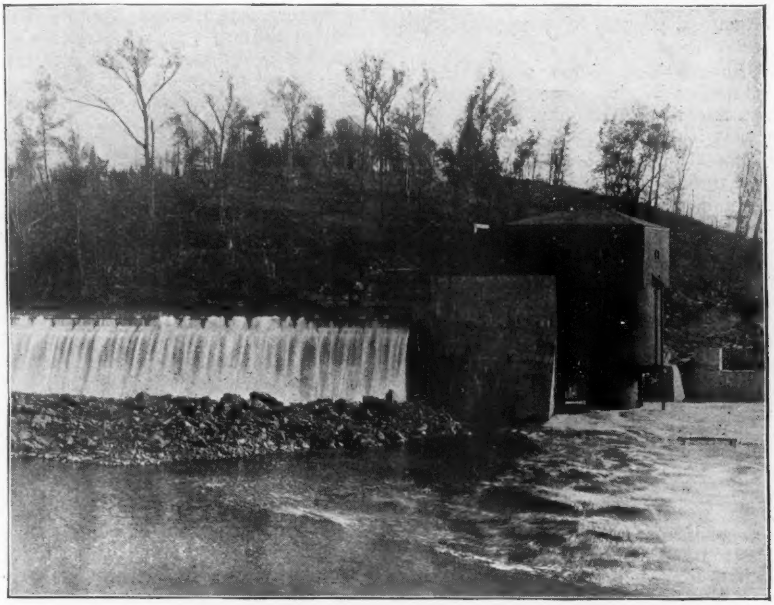


FIG. 9. VIEW OF PORTION OF DAM-COMPRESSOR UNDER CONSTRUCTION.

Mr. McKenzie—What is the method of introducing the air into the water as it passes down?

Mr. Shedd—That has been done in various ways. At Magog it is done by a series of three-quarter inch pipes surrounding a circle, the upper ends above the level of the water and the lower ends at the point of the greatest velocity of the water as it flows into the down-flow pipe. The water passing by the end of the pipe tends to create a vacuum there and the

pipes to these gridiron bars rise above any possible level of the water in the headpiece. They are 12-inch pipes with a 36-inch centre pipe.

Mr. Fuller—I should like to ask Mr. Shedd with regard to the excavating of the well, whether that was expensive? I suppose there was a good deal of water which had accumulated which had to be constantly pumped.

Mr. Shedd—Very little, indeed; it was very favorably situated in that respect.

Down perhaps one hundred feet there was one seam which developed a pretty good flow of water, but otherwise the ledge was tight. That inflow was taken care of by an excavation in the side of the shaft and a dam between that and the shaft itself, making a well, out of which the water was pumped. We then had no more water to amount to anything until we were at the bottom of the shaft.

Mr. Fuller—How much did that excavation cost per cubic yard?

Mr. Shedd—I shall have to tell you from memory, but I think it was $3.50 a cubic yard.

Mr. McKenzie—Are there any patents on the general process of compressing the air?

Mr. Shedd—Yes. That was patented by a Canadian by the name of Taylor, in England and in this country.

Mr. McKenzie—Is there a royalty paid?

Mr. Shedd—That I don't know. I don't know what their business arrangement is, but I think the Norwich people are licensed by Mr. Taylor.

Mr. Sickman—What is the temperature of the exhaust at the engine?

Mr. Shedd—That varies. It is very low in cases. It has been low enough to freeze. We had no difficulty in Magog, but here there has been slight amount of moisture, and the temperature due to expansion is low enough to freeze that moisture unless the air is reheated. But when the air is reheated, which would, of course, be done in all cases if you are seeking economy, then there is no trouble of that sort. There have been a good many experiments made on the temperatures both of the air admitted and the air discharged, but I don't remember the figures. Our experiments showed that from about a third to a half as much moisture was in the air delivered by the compressor as was in the atmospheric air from which it was drawn; that is, the air has been made dry by being enclosed in water.

Mr. T. W. Mann—In 1876, I think it was, I was in Rochester, and they had a system of two tubes which were air-tight and they let the water in at the bottom and compressed the air in one tube while the water was going out of the other tube, keeping a balance of pressure. I wonder whether that would not be a pretty good way to keep the moisture out.

Mr. Shedd—I don't know, myself, about the process the gentleman speaks of, but I should think it might be very much in theory like a process designed by Mr. Joseph P. Frizell, twenty years or more ago, for compressing air. He had a shaft above a dam down which water went carrying air with it and then he had a horizontal tunnel and a shaft below the dam so that there was a difference of level below and above the dam, and at an intermediate point he had a chamber in which the air was collected. I should think that would be similar to having two pipes. There have been a great many ways of entraining air and compressing it by water, and I think Mr. Frizell's was perhaps the first really practicable scheme. But that never has been put into commercial use, so far as I know, because it was an expensive process as he designed it.

Mr. Atkinson—I happened to be in Liverpool some twenty years ago and went to the great docks, and I found that all the power used there was compressed air. Of course, it would be very dangerous to have fire among the merchandise there. I am not mechanic enough to understand the details of it, but if any of you visit Liverpool I think you will find that the use of air pressure throughout the docks is very extensive. I once gave a hint to a mill man which may be worth the telling here. You all know that the fiber of cotton is exceedingly susceptible to the changes of temperature and humidity. Now, the air which goes down through the wheel pit gets washed and cooled. In the case of the gentleman to whom I refer the basement of his mill was on a level with the tail race, and in hot weather it was very damp and very objectionable. I suggested to him to put an air drum over the water in the wheel pit and to carry the cool, dry air through a pipe into his picker room and from his picker room into the spinning room, and thus overcome the humidity. He adopted the suggestion and it worked very successfully. That same thing can be done in many places. There is an enormous quantity of air which goes down through the wheels, even without any artificial method of carrying it. I have been told that at a summer resort in Austria a mountain stream has been used to compress air, and one of the show features is to let the cool air out in midsummer and produce an artificial snowstorm. There is a head of about eight

hundred feet which gives an enormous pressure.

Our old friend Sam Webber had an entirely new device for compression which he has described to me, and it made such an impression on me as it would naturally make on a "duffer." It was entirely different from Mr. Frizell's, and quite different from the one which has been described to-day. Then, I remember some twenty years ago the Plymouth Cordage Company desired to install an engine for hauling heavy stuff through their yard, and we objected to it. There was then devised an air locomotive and we sent the designs to the Boston Locomotive Works, who built it without giving any guaranty that it would be efficient, but that little air engine is operating to-day, carrying around the heavy stock in the yard. When I returned from Liverpool I reported to the Cotton Manufacturers' Association that the English were a generation ahead of us in this country, but we appear to be catching up with them now in the use of air pressure.

FIG. 10. BLOW-OFF IN OPERATION.

Each method of producing or transmitting power, whether by steam, or gas, or oil, or electricity, or compressed air, has advantages of its own under favoring conditions, but the use and value of compressed air seems heretofore to have been but partially known and poorly appreciated. I quote from Richards: "The use of compressed air has been slow of development, and is still backward, but at this writing I am able to enumerate two hundred distinct and established uses of compressed air, and in more than ninety per cent. of those uses electricity is absolutely inapplicable, and in the remainder, which form a field more or less open to other agencies besides either air or electricity, the air generally has the advantage."

In the Norwich plant the production of compressed air is very uniform and the pressure is held steadily at about ninety pounds while the compressor is in operation. A card from the pressure recording gage shows that the pressure for the whole twenty-four hours varies only about

two pounds, standing at just ninety pounds nearly all the time. The water, when this card was taken, was turned through the compressor, beginning at a little before five o'clock in the morning, and in about ten minutes the card represented the full amount required to carry the pressure from that existing through the night to the ninety pounds which is the standard pressure. At about fifteen to twenty minutes after five in the morning, the distribution pipes are blown off, to free them from any possible moisture which may have gathered over night, and this operation is shown by the reduction in pressure of about one pound. This pressure is, however, restored in amout ten minutes, and from that time to midnight the full pressure of ninety pounds is uniformly maintained. After that time until 4.45 in the morning the pressure shows a gradual reduction of about two pounds, but I am informed that this is not probably the result of leakage, but that small amounts of air are drawn, for various purposes, during that period in the night. Daily cards are taken, the change from one card to another being made at about nine o'clock in the morning.

The air delivered from the Norwich plant is in use in over forty engines, and its employment is a source of great satisfaction to the men who formerly were obliged to reach the works by 4 or 4.30 in the morning, to get up steam and have everything ready to start at 7, and who now have the comfort of waiting until a few minutes before 7. Upon arrival they simply turn a valve and the machinery starts off at full speed.

Discussion.

Mr. Edward Atkinson—I should like to ask if this power is sold.

Mr. Shedd—It is sold to various small factories in Norwich and vicinity, which formerly used steam and are now using compressed air in its place. I have nothing to do with the financial part of the business, and I do not know what the prices charged are, but these concerns at least have preferred to use air at the price at which it is sold rather than steam, which they had been using.

Mr. Atkinson—It was a question in my mind as to whether at the price at which it is sold it pays the promoters.

Mr. Shedd—That I am unable to say.

Mr. T. H. McKenzie—Are the pipes laid as water pipes are, below the frost?

Mr. Shedd—No; most of them are about four feet deep, but really there is no occasion to lay them below frost, except that it is desirable to have them so low that they will not be thrown by the frost.

Mr. McKenzie—Why does the air blow-off blow both water and air?

Mr. Shedd—Because the inlet to the blow-off pipe is just at the level of the air and water, and as the air begins to pass out it carries water with it, so that water and air are discharged.

A question has been asked me as to how the flashboards have worked in practice. The only trouble they have had from the flashboards has been that when they are open leaves flowing in the stream sometimes catch in the seats and flashboards do not entirely seat themselves afterwards, so that there is a little leakage for a time until the leaves are cleared from under the seat.

Mr. Frank L. Fuller—I should like to ask Mr. Shedd in regard to utilizing the different amount of flow at different seasons of the year. I think all the slides which were put upon the screen showed water running to waste.

Mr. Shedd—Yes; the plant is adapted to 1,500 horse-power, and the stream is usually capable of developing considerably in excess of that amount of power. Water, of course, is running to waste over the dam when there is only 1,500 horse-power or less going through the compressor. When the compressor is taking a less quantity, adjustment is made in the head-piece.

Mr. Fuller—I presume it is quite a variable stream.

Mr. Shedd—Yes; but it is pretty well reservoired. As near as I remember, there are forty-three different storage reservoirs on that stream. It rises in Worcester County in Massachusetts, and there are a great many mills on the stream; it has been very well developed for manufacturing purposes.

Mr. Fuller—Could not another compressor be used when there was plenty of water?

Mr. Shedd—Yes; there is an opportunity to place another alongside of this one. Everything has been so arranged that no disturbance would occur if another com-

pressor of equal capacity were set alongside of this.

Mr. McKenzie—Is there any patent on the apparatus for the flashboards?

Mr. Shedd—Yes, there is.

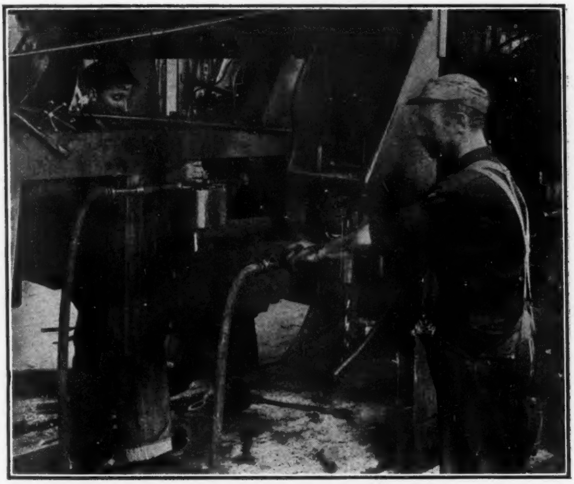
Mr. McKenzie—Who owns it?

Mr. Shedd—I guess it is pretty nearly free.

Mr. McKenzie—What do you mean by its being pretty nearly free?

Mr. Shedd—Well, there wouldn't be much objection to anybody using it for these purposes.

Mr. Albert F. Sickman—I would like to inquire if you know what the efficiency of this compressor is?



WORKING IN CLOSE QUARTERS.

Mr. Shedd—The efficiency has not been measured at this place particularly, but I took part in several experiments as to the efficiency of the plant of Magog, and that ranged from about sixty-two per cent. to a little over seventy per cent. The highest efficiency we obtained was a little over seventy per cent.

Applications of Pneumatic Power in the Machine Shop.

There was a general tendency during the nineteenth century toward the centralization of prime-movers and the operation of all classes of machinery by transmitted power. Among the most common systems of distribution are mechanical (shaft, rope, belt or chain); hydraulic, pneumatic and electric. The mechanical distribution systems are costly to install, and somewhat cumbersome; their practical range is but a few hundred feet.

Hydraulic transmission is objectionable for general use because of the many leaks, and the problem of disposing of the "used" water. Pneumatic transmissions, unless carefully designed, are subject to water-condensation troubles and to invisible leakage. If proper care is exercised to install pipes and joints that do not leak, the practical radius of use (while not usually comparable in length to long-distance electric transmission) is very considerable; and in special cases the system has a number of advantages over electricity. The relative generating, transmitting and operative efficiency, in shops or works installations, or in small plants, is not in favor of electricity; although the costs of piping and wiring, for equal powers, are comparable, the initial costs of generators, *versus* compressors, of electric *versus* air motors, of transformers *versus* reservoirs (not to speak even of switchboards) are greatly to the advantage of the pneumatic equipment.

*By R. Emerson, in *The Engineering Magazine*

The lack of danger in an air system has been cited—an important feature in tools working in close quarters on metals; and the greater portability of the air tools now on the market compared with the electric contrivances thus far in general use in the United States and in Germany, is a point of advantage that every shop man (and shop men must use the machines) will vouch for. A further underlying advantage is that electricity is used practically to impart rotary motion alone, whereas air has an endless variety of uses. Thus it is that compressed air has found favor in mining, bridge and ship-building, structural steel work, in erecting-shop work; that in a recent large quarry installation it was preferred, though the lines ran two miles from the power plant; that in the early development of Niagara Falls as a power centre, it was proposed to use compressed-air transmission, and that in British Columbia, at Ainsworth on Kootenai Lake, an automatic air-compressing plant is delivering compressed air to miners within a radius of several miles. Modern railroading, as a further instance, with its high-speed and heavy trains, would have been impossible without the air brake.

The great variety of uses to which air power can be put has made its development rapid and extensive and its effect on prevailing practices and methods has been so marked as almost to revolutionize every important line of modern engineering. Stone cutters, rock drillers, motors, hammers, yoke riveters, hoists, lifts, presses, carpet cleaners, sand blast, painting machines, conveyors, bolt nippers, jam riveters, flue cutters, holder-ons, air jacks, sand rammers, bell ringers, sand sifters, fire forges, brazing and welding flames—these are a few of the less well-known uses of compressed air.

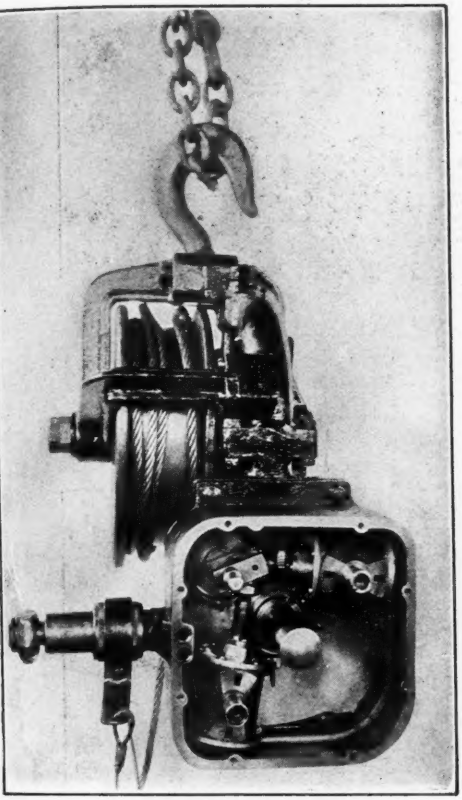
Pneumatic and electric motors do not "generate" power; they turn into useful work the energy transformed through them. Both electric and pneumatic motors are of such recent development that many practices that ought to be obsolete still prevail, especially in railway shops, where competition does not exert the same stimulus as in commercial shops.

ONE MAN REAMING IN BOILER STEEL.

The shops of the immediate past had a main shaft driven by a Corliss engine. This shaft drove all the machine tools. There was either a mechanical or a hand crane—or none at all—over the erecting or assembling floor. Present practice drives generators direct by high-speed "automatic" engines; takes the current to large 20 or 30-horse-power motors (relegated to the rafters in the shops), each

driving a "group" of machines, through main and countershafts, some heavy machines having individual motor-drive; and also installs an air compressor, reservoir and piping, with motors and hammers for use on the floor and outside.

While it is probable that individual and group drive will be retained much as at present, the impending advance in shop



INTERNAL MECHANISM OF AIR HOIST, SHOWING THE SMALL PNEUMATIC ENGINES DRIVING THE WORM OF THE WORM GEAR.

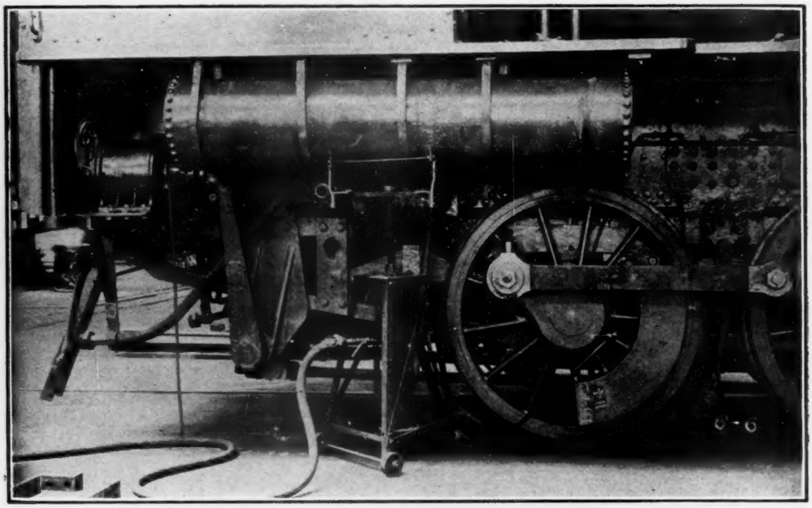
betterment with increase of capacity, indicates that many heavy operations will be done by portable tools (whether light electric or air, or the heavier electric-driven machines carried on trucks or transferred by crane) avoiding the effort of moving the mountain to Mohammed. It is this phase of the question that interests us, for it means a transformation not only of work done by hand to work done by power, but also transplanting of work done in the machine shop to work done on the floor, and the savings and economies to be effected will be considerably greater than those obtained through individual or group electric machine-drives—greater even than those obtained by high-speed steels. For example: If it takes 14 hours to set up a job and 6 to do it, of which during less than 3 a high-speed tool is actually cutting, a saving of 10 or 12 hours might be realized by moving a portable tool to the part to be repaired or machined.

A few years ago (and even in some shops to-day) all drilling, tapping, chipping, calking, riveting, reaming, flue rolling, grinding of joints, cutting, beading, valve-seat facing, ramming, etc., was done entirely by hand, and there was no such thing as an air-lift to handle work for heavy machines; to-day all progressive shops are dependent on air for economical production.

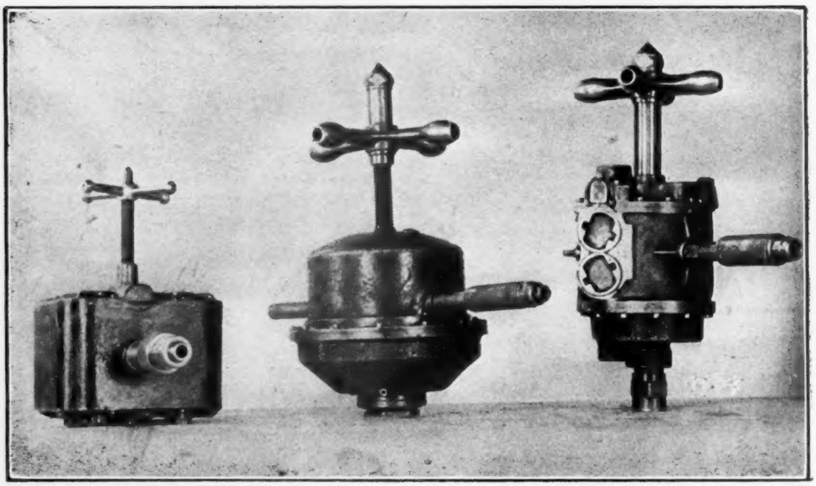
The Evolution of Motors into Modern Types.—Having a general conspectus of the field of work to which portable power-driven tools are applicable, it is interesting to note the recent development and improvement in design of these tools before passing to the consideration of intrinsic merits of modern types.

The earlier motors were heavy and unwieldy compared to those now in use. One of the first was the product of a boiler-shop foreman in a western railway shop. Later, an improved motor, and an air hammer, were developed. A young mechanic, seeing this hammer in operation and realizing its advantages in chipping castings, introduced himself to the inventor, who in a small shop employing four or five men, was making these tools.

The mechanic, who was an able demonstrator, combined with this quality an unusually pleasing personality, great imaginative foresight, organizing ability and unbounded enthusiasm. He agreed to take, and to sell, the entire product of the little shop. Within twelve months the shop output had been increased manifold, and a few years later the inventor was enabled to retire with a large fortune. Great credit must be given to these pioneers through whose efforts this inno-



NEW METHOD OF JACKING AIR RESERVOIR WITH AN AIR-OPERATED DRUM HOIST. IN MARKED CONTRAST TO THE OLD CUMBERSOME BLOCKING-UP.



TYPICAL MOTORS, WITH FEED SCREWS EXTENDED.

vation was put into practical and economical use. It is no small achievement to change radically time-honored methods of the mechanical trades in the space of less than a generation, especially when it is realized that the machines in question were far from being perfect when they were first taken hold of by these men.

This brief sketch illustrates the newness of the air-motor as a practical machine, and its rapid extension to many lines of work.

The early motors were unwieldy and inefficient to such an extent that there was great difficulty in persuading men to use them the stimulus to make a machine that would not only do the work—do "hand" work in very close quarters—but that would also be easy and convenient to use—that would save, not increase, the man's effort. Realizing the necessity of securing the hearty and willing co-operation of the workers, shop officials have become more critical, have instituted tests of efficiency and power, of durability, and of economy of maintenance in proportion to weight, and these tests have thus reacted on the business of the manufacturers, forcing them by competition to improve their air tools.

A "HAND" JOB DONE BY AIR.

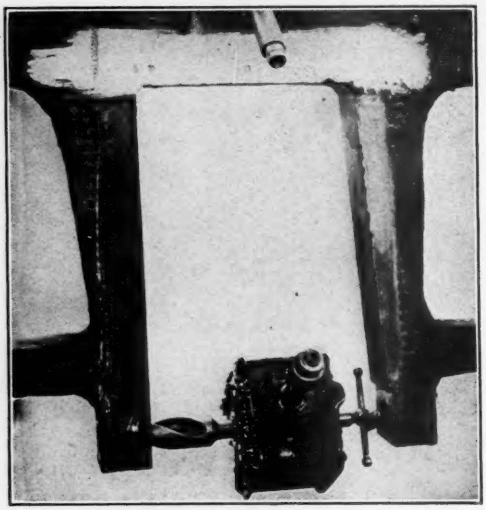
Drilling in a locomotive fire-door.

them. "Old men," dogs, braces, clamps, had to be rigged up before the machine could be used; but even with a helper (and the weight and vibration of the motor necessitated two men) the men were loath to employ air tools, because of the difficulty in handling. The average man on day work seeks not how quickly, but how easily, to do a job.

Productive Efficiency in the Shop.—An air tool, however, like all other machinery, is intended as a help to the men and the work, and not as a hindrance, so rival manufacturers have continually had before

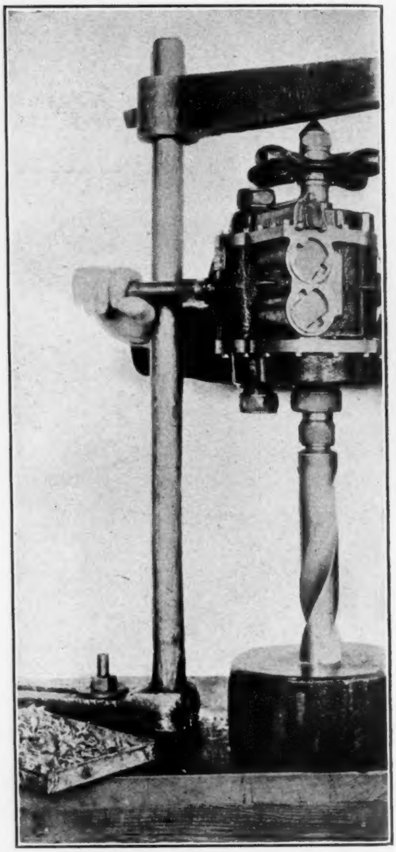
As an instance of the interest and influence of users of air tools, a railroad official asked various manufacturers to submit their most efficient and useful machines for test. These and some six of the older type machines were thoroughly tested, at various speeds, under various loads, and with different air pressures. Gauge, meter, scale and revolution readings were taken at half-minute intervals, and endurance tests of half a day were also carried out. From these tests, and from records kept of service of motors and of itemized repairs made to each ma-

A "HAND" JOB IN NARROW QUARTERS.



DRILLING FOR PEDESTAL BOLT HOLES IN A LOCOMOTIVE FRAME.

chine, extending over a period of two years, the data in the accompanying diagrams are taken. Consequent upon the tests and their calculated results, orders were placed in several sizes for a number of each of the best machines. These machines, allotted to certain men and gangs in the shops, came at once into general favor, and owing to a rigorous system of inspection and repair (blank forms of the records of which are here-

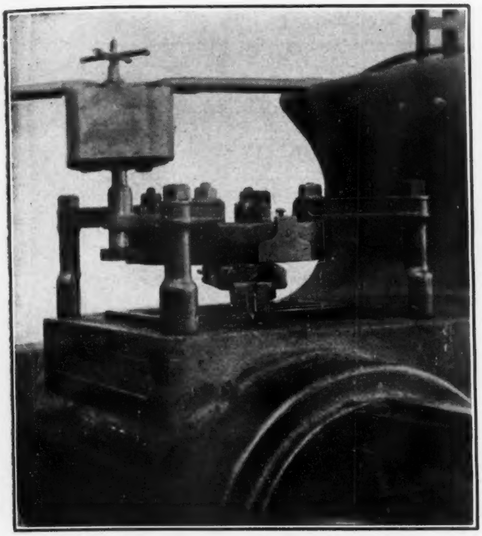


MODERN HEAVY DRILLING WITH AN "OLD MAN."

with shown), their efficiency was far higher than had been the case with the older machines, while the repair cost per hours worked fell below that of previous experience.

Certain of the machines were not assigned to definite gangs, but were for

general use. The men who had need of a machine demanded one of the new ones. One make of machine was in particular favor because of its lightness. In fact, there were cases where men had to be disciplined for failing to turn in motors on Saturday night for inspection, because



VALVE-SEAT-FACING ARRANGEMENT.

Hitherto undesirable jobs of reaming and drilling in contracted spaces were made so much easier that they were no longer shunned. The one item of reaming holes alone was cut to less than one quarter the former labor cost, when a heavier type of machine was used. This was due to the fact that the mechanic did not need a helper and could work more quickly and to better advantage.

It will be noted that a number of repair items in the sample record illustrated are quite heavy; and it should be explained that these machines were the total of those "out-of-business" among over one hundred in use in the shops, and that as there was a system of pay in effect rewarding men according to their individual effort, it was considered greater economy to wear out the machine by continual and heavy service than to save the machine at the expense of shop output costs.

Comparative Motor Performance.—There is subjoined an outline drawing showing the general dimensions and sizes of the five principal motors put on the market in the past ten years. These motors have all received extensive use and are the best representatives of the most successful, mechanically and commercially, of the motors of the period mentioned. They are arranged, with one exception, in the order of their appearance on the

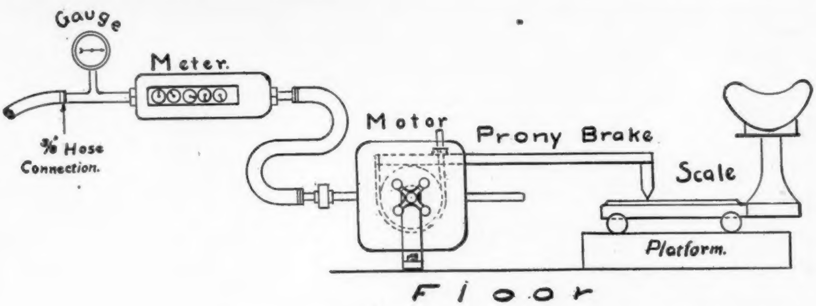


DIAGRAM OF METHOD OF TESTING MOTORS.

they feared that they might miss getting the same machine Monday morning. Men who would not use a motor previously now began proposing its application to all kinds of jobs, and results in most cases justified in complying with these suggestions.

market and the progress in lightness and compactness is very evident.

Some of the data obtained in the motor test are worthy of attention. The cost of compressed air was determined by a thorough one-week's test of the power plant. In the diagrams the small circles

BLANK R·R·COMPANY

Individual Motor Work Report

Date	Make	No.	Work:
Feb 3	D	34	Broken toggle
"	a	8	Broken piston, and bent rod
"	D	32	Broken toggle
Feb 4	B	20	Cracked Cylinder
"	B	23	Cracked Cylinder
"	E	51	Broken casing
"	D	31	New toggle and worn-out crank
Feb 5	D	34	Pins replaced in toggle
"	X	16	Valve repaired
Feb 6	B	26	Cylinder broken; new packing rings

FORM FOR RECORDING AIR-MOTOR REPAIRS.

BLANK R·R·COMPANY

Date	Make "A" No.	Sz	Hrs	Make "B"			Make "C"			Make "D"			Make "E"			Misc. Makes		
Feb 3	8	2	3							32, 34	1	5						
Feb 4				20, 23	4	8				31	1	½	51		1½			
Feb 5										34	1	2				X 16		1
Feb 6				26	5	6												

FORM FOR RECORDING HOURS OF LABOR, INSPECTION, CLEANING AND REPAIR SPENT UPON EACH MOTOR.

	BLANK R. R. COMPANY																		
		Make "A"			"B"			"C"			"D"			"E"			Misc		
	Date	No.	G'g	H'rs															
	Feb 3	1	C	10	20	409	4	81	M	10	30	308	10	51	65	8	X 16	348	5
	"	2	103	8	21	338	10	82	M	9	31	409	5	52	L	7	Q 18	B	3
	"	4	H	9	22	118	8	83	E	10	32	B	6				Z 71	243	8
	"	5	K	0	23	H	2	84	-	0	33	H	5				Z 72		0
	"	6	345	2	24	143	7				34	K	10						
	"	7	B	7	25	-	0				35	-	0						
	"	8	M	1	26	C	0												
	"				27	-	0												

FORM FOR RECORDING HOURS OF SERVICE OF EACH MOTOR.

"G'g" means gang (or man) using each machine. All the forms shown are 8 by 5 inches, the horizontal lines being spaced $\frac{1}{3}$ inch apart; ruled in light blue except the dotted lines, which are red; printed in brown.

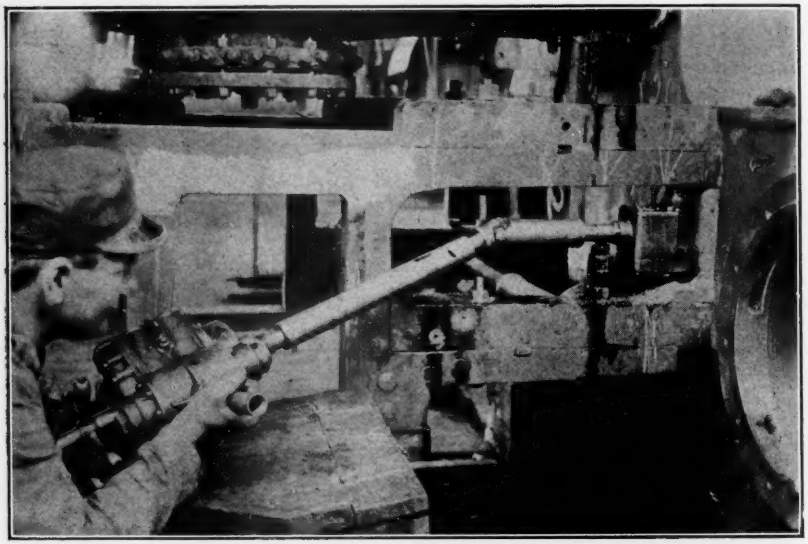
GETTING MOTORS FROM THE TOOL ROOM.

represent the five motors in the order in which they appear in the outline drawing. It will be seen that the net purchase price (in quantity) of these tools has slightly decreased, yet the design has been improved. The efficiency of the motor has increased in every way, also, in a surprising degree—the losses in the older types being due to large leverages and consequent working loose and wearing of parts, and to poor piston fits. It should here be stated, however, that in this series of tests the machines selected were all in good condition, the new ones having been "warmed up" by a few weeks of "active service" and the older machines having been previously put in thorough repair and adjustment, so that each machine might give the best performance of which it was capable.

Referring to the last of the three diagrams, the line representing relative costs of operation per unit of work is most striking.

The earlier casings and parts were heavy and large, to withstand as yet undetermined strains. Little attention was paid to the selection or testing of the materials used in the motor. The tool was driven at a point far away from the crank, and as no provision was made for balancing, the vibration was excessive. The oiling also was unsatisfactory. In the old "wing"-type motors it was difficult to keep the mechanism properly oiled, as the air driving the motor carried out the oil in the exhaust. In the later types, the cranks run in oil, and the air comes in contact with the piston only.

Simplicity of design, compactness, fewness of parts, are the elements that characterize the later types of motor. The strongest motor is not the heaviest; the most powerful is not the largest.



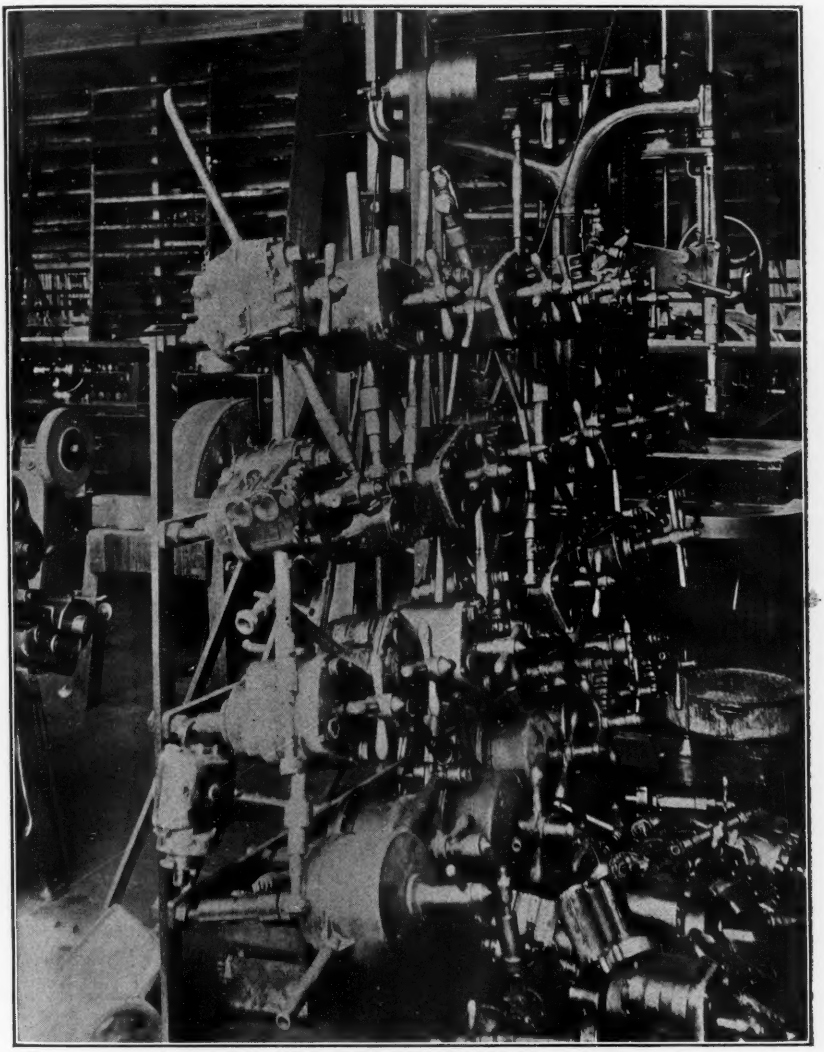
AN "UNDESIRABLE" JOB, MADE EASY BY USE OF ANGLE DEVICES IN CONNECTION WITH AN AIR MOTOR.

In examining into the reasons for the increased economy and compactness of the later types in proportion to power developed, it may be stated that a higher number of revolutions of tool-socket per minute has been one of the factors. In one of the later types a two-speed gear provides for both slow and fast operations and this has been found of great use.

An important point is that in the earlier types, the repair and maintenance costs, as well as the operative costs, were excessively high, and that owing

to this condition, the time lost by the machine to productive service was very great. Even under these disadvantages the early machines were able to compete economically with hand labor; and now it is a very favorable sign that the tendency is toward:

Decrease of weight, decrease of first cost, decrease of maintenance cost, decrease of operative cost, increase of effi-



CONVENIENT RACK FOR STORING AIR MOTORS.

Designed by a tool-room machinist.

ciency and economy, increase in applicability to various classes of work, increase of time in service.

While it has been shown that the air motor has well earned an important place in modern industry, and is likely to extend its usefulness, it cannot of course be claimed that the field of power-driven portable tools will be held exclusively by pneumatic tools. There are certain classes and conditions of work for which they are peculiarly adapted, and in general practice, for reasons already mentioned, they will hold their own for long to come over electric and other rivals.

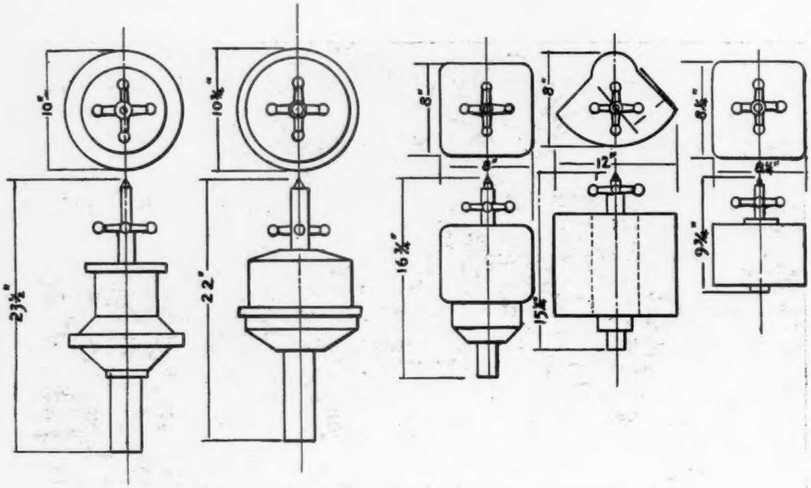


DIAGRAM OF COMPARATIVE SIZES OF MOTORS.

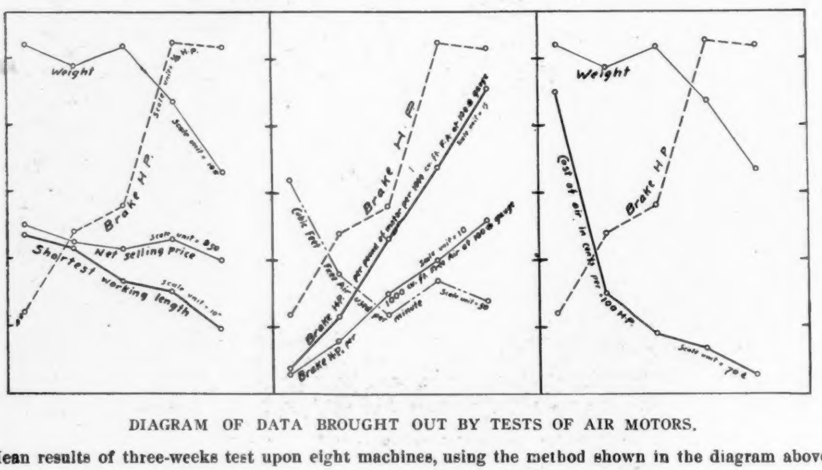


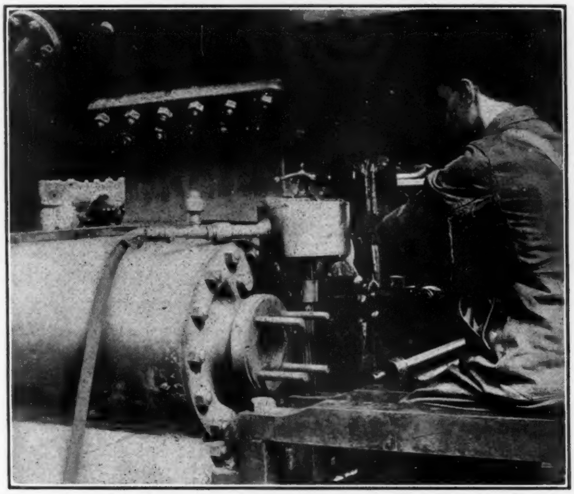
DIAGRAM OF DATA BROUGHT OUT BY TESTS OF AIR MOTORS.

Mean results of three-weeks test upon eight machines, using the method shown in the diagram above.

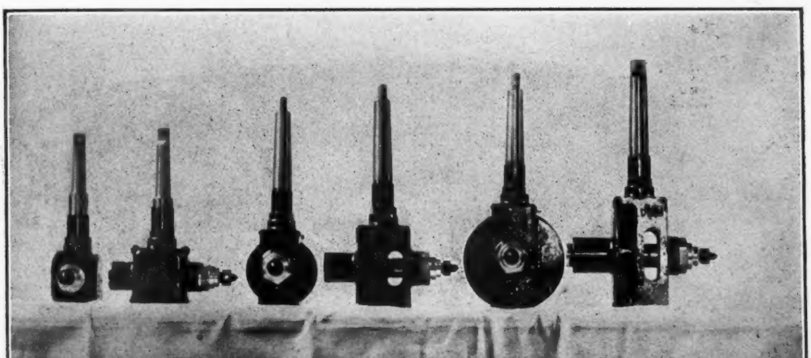
Portable Electric Motor.—In the past the electric motor has been handicapped in its introduction as a portable tool be-

cause of its great weight and comparatively high first cost, proportionate to horse-power developed. For this reason the air motor has held a virtual monopoly of this class of work, even in this "Age of Electricity." Owing to great improvements in design in the past two years, such as air-cooling of coils, etc., the electric portable motor is coming in for serious attention for practical shop-production improvement. An even further reduction of some 10 per cent. in weight is possible by the use of aluminum in armature and field coils.

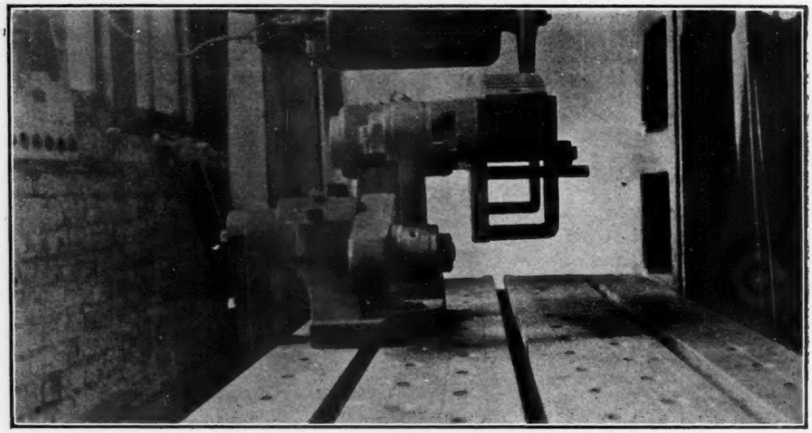
The illustrations show one type of portable electric motor, attached to a planer, grinding links which are given the proper motion by a jig on the bed of the planer. The common cord and Edison plug are used to make connections with great convenience. While these motors are quite light, there is prospect of their being made still more so in future.



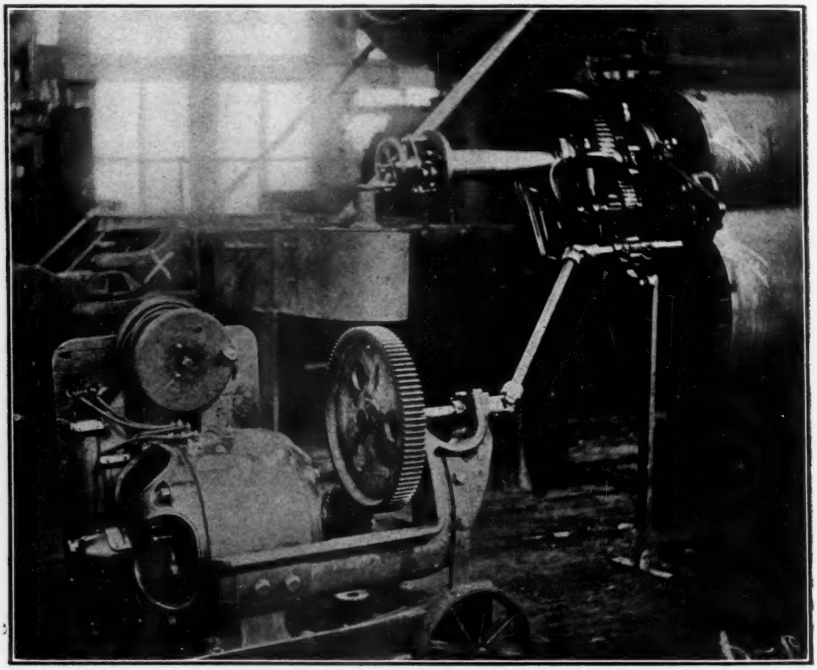
A FORMERLY "UNDESIRABLE" JOB OF REAMING, NOW DONE COMFORTABLY BY AIR TOOLS.



A GROUP OF ANGLE DEVICES FOR USE WITH AIR MOTORS.



PORTABLE ELECTRIC MOTOR CLAMPED TO A PLANER FRAME, ENGAGED IN GRINDING LINKS FOR LOCOMOTIVE.



A TRANSPORTABLE ELECTRIC MOTOR.

Although these motors are too new upon the market to venture any data as to their permanent efficiency compared with air tools of the same capacity, it may be said that they will find a very ready use in shops not at present equipped with an air-compressor, where electric energy is available. Automobile plants, buying their current, will especially find their use economical.

Considerations Governing Purchaser.—Not always having the advantage of special knowledge, or of experience, and lacking time and facilities for testing out before purchase, works managers and superintendents may be in doubt as to the paying value or comparative worth of all the machines and devices drawn to their attention by enterprising supply companies. To such men on the look-out for improved methods, and indeed to all intending purchasers of air-tool equipment, three main considerations are presented:

The tool should be of general adaptability. This is most important, and should largely govern the selection.

It should be maintained and operated at low cost.

Its first cost should not be prohibitive.

As is usually the case, the simplest and most compact motor, of light weight, of few parts, is at once the most adaptable, easiest to maintain and cheapest to make. Fewness of parts calls for less material and less labor per piece. Assembly costs are less, as cheaper labor may be employed. What is here said of manufacturing costs applies equally to repair expense; with fewer parts there is less liability for wear, for lost motion, for breakage; there are fewer "extra" pieces to carry in stock, and there is increased time service.

No one cares to invest in a high-priced tool whose use is limited to a small class of work. I have seen contract shops loaded down with useless and expensive machinery, much of it standing idle the greater part of the time. In many modern railroad shops the machine equipment is ill chosen, this being the main cause of the high repair costs prevalent in the last few years. If, however, one can be assured that the tool to be purchased, whether a heavy machine tool or a portable one, will be in constant service, the investment is well worth while.

The Force of Percussion in Pneumatic Hammers and Drills.

BY C. CHARLES MAISON.

The force of a blow from a hammer in the hand, of a drop press, a pile driver, a hammer, a rock drill, the falling of solid bodies, the water ram in pipes, and the power of projectiles, produce effects deductible from the general laws of dynamics applicable to such work. The power of the hand hammer, which has not yet been classed among the "mechanical powers," without doubt deserves the place of much honor as the most ancient and, in many respects, the most wonderful mechanical power known in its way. We daily see results of its surpassing force, effected without the complication of levers, wheels or wedges, and apparently having some inanimate power superior to and independent of the principles of mechanics as commonly studied. In order to enable any one to make the complete computation of the velocity of a drop hammer in the drop press, a cushioned air hammer, or the monkey pile driver, where the velocity is due to gravity only, the power of impact at the moment of giving the blow may be ascertained from the known height at which the velocity of fall commences. The effect due to cushioning of air and spring hammers will be an acceleration of velocity due to the gross pressure at the starting, and will be described.

The square root of twice the gravity ($\sqrt{64.33}$) multiplied by the square root of the height ($\sqrt{\text{height}}$) in feet; $\sqrt{2g \times h}$, or $8.02 \times \sqrt{h} =$ the velocity in feet per second at the constant of impact of a falling body. Then one-half of the velocity $\times$ by the

$$\frac{\text{weight}}{\text{gravity}} \frac{v^2}{2} \times \frac{w}{g},$$

or more simply, the height of the fall $\times$ bv the weight, gives the number of foot pounds due to the fall, and the distance at which the force of the blow is arrested is the measure of the force of percussion or impact. It is as much more than the momentum in foot pounds as the distance of arrest bears to a foot. Thus, if at half a foot the impact is twice the foot pounds, of one inch it is 12 times, at ¼ inch it is 48 times, and at 1-32 inch it is 384

times. This latter arrest represents the impact of hardened surfaces, where the elasticity of the metals largely represents the small movement, at impact, and of which the rebound of a hammer from the face of a hardened anvil represents the reactive effort of the foot pounds due to the momentum of the fall.

A small hammer simply wielded will accomplish that which would otherwise require a direct pressure of several tons. Seeking the cause of its mystic power or energy stored in weight and velocity will account for the varied effects we obtain. In striking a blow with a hammer upon the head of a chisel there are two forces brought into action, viz.: the force of striking and muscular force to increase the velocity, so that at the instant of striking, the hammer may have a velocity of from 20 to 50 feet per second. The effect at this moment is the same as if the final velocity had existed throughout the whole of the stroke. Assuming 32 feet per second as the actual velocity at the moment of impact, then the force will be the same as if the hammer had fallen from a height of the square of the velocity divided by twice the gravity

$$\left(\frac{v^2}{2g}\right) \text{ or } \frac{32^2}{64.33} = 16 \text{ feet.}$$

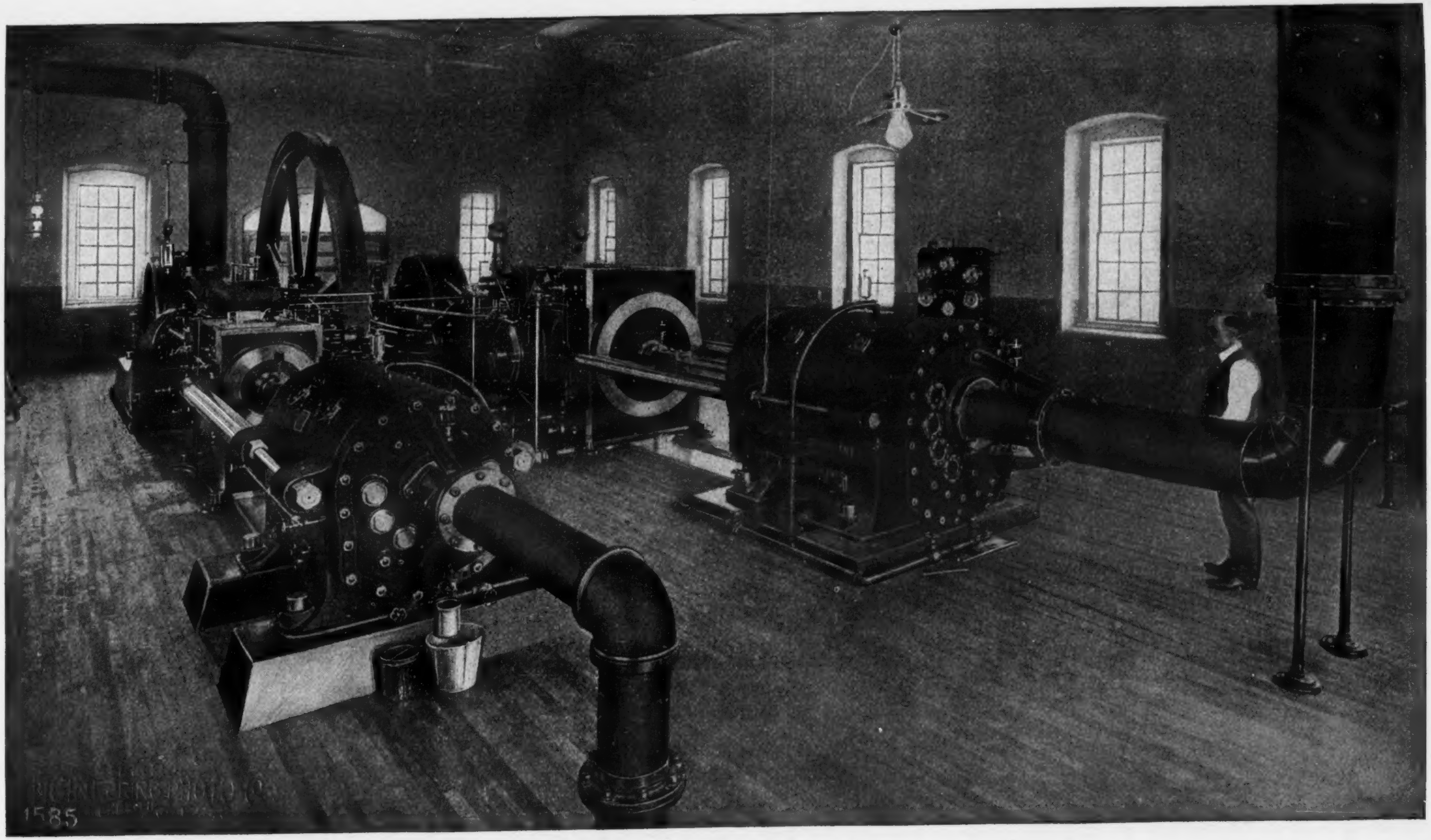
With a hammer weighing two pounds, then, the accumulated work or energy will be $16 \times 2 = 32$ foot pounds.

Supposing that the face of the hammer moves one-eighth of an inch after touching the head of the chisel before the energy is all absorbed, then the result will approximately be the same as a direct pressure or dead load of $32 \times \frac{12}{\frac{1}{8}} = 3{,}072$ pounds or upward of $1\frac{1}{2}$ net tons; but this is only partially true, however. The hammer may be a self-adjusting, mechanical power; for if the material be harder, so as to give more resistance to the chisel, the cut will not be so great, and therefore the force of percussion will be greater. For instance, if the movement of the chisel, as above stated, had been only one-sixteenth of an inch, the force would have been doubled, or equal to a pressure of 3 tons instead of $1\frac{1}{2}$ tons. But there is a limit to the effect, otherwise the blow would be measured by thousands of tons, until the rigidity of the mass receiving the blow was balanced by the elasticity of the material giving or receiving the blow. This is beautifully illustrated when striking the hardened face of an anvil with a hammer, where nearly the whole force of the blow is returned in the rebound of the hammer.

Compressed Air at the Mohawk Copper Mine, Calumet, Mich.

Copper mining in the Michigan district is expensive. The great depths required, and the low values of the ores entailing the handling of great quantities of rock, make mining costs high and compel close economies to place the mines on a paying basis. This necessity for low operating charges has led to the adoption of high-grade machinery equipments on the Michigan copper mines. Conspicuous among all these equipments are the air compressors, so essential to successful operation. These latter machines are in the great majority of cases of large size and the very highest grade, and the machinery plants of mines in this district, as a rule, represent the highest type of mine power plants. Corliss compressors predominate, owing to their superior steam and fuel economy.

The Mohawk mine, located in the neighborhood of Calumet, Michigan, while one of the newer properties, is one of the most promising mines in that district, and was credited in 1904 with a production of 8,500,000 pounds of refined copper. One of the largest Corliss compressors in the copper district is found on this mine and was built and installed by the Ingersoll-Sergeant Drill Company of New York. The machine is a cross-compound steam, two-stage air compressor having a rated capacity of 5,260 cubic feet of free air per minute at normal speed of 70 revolutions per minute. The steam cylinders are 22 inches and 46 inches in diameter, and are of the latest pattern, with standard Corliss release gear and a steam receiver located in the foundation beneath. Steam pressure is 125 pounds. The gauge on steam receiver indicates a pressure of about $6\frac{1}{2}$ pounds and the engine runs under a vacuum of 25 inches. The exhaust is handled by a jet condenser located with its auxiliaries in the basement below the engine room. Pressure is maintained constant by means of a combined speed and pressure regulator which varies the speed and displacement by changing the cut-off on both steam



POWER HOUSE OF THE MOHAWK COPPER MINING COMPANY AT CALUMET, MICH.

cylinders. Air cylinders are 42¼ and 27¼ inches in diameter, with a stroke of 48 inches. They are completely water jacketed on heads and barrels. The Sergeant piston inlet valve is used on both high and low pressure cylinders and the low pressure intake is connected with a sheet steel intake connection drawing cold clean air through a conduit rising above the roof of the power house. The discharge valves are of positive direct-lift pattern, giving maximum discharge area with a minimum of cylinder clearance. A large horizontal intercooler below the engine-room floor cools the low pressure air discharge to water temperature by contact with surfaces cooled by water circulating through tinned brass tubes.

An independent direct-acting circulating pump in the basement handles the cooling water for cylinder jackets and inter-cooler. Steam pipes for the compressor and auxiliaries enter the basement of the power house through a tunnel leading to the boilers in a separate building. The power house is a stone building with a steel-framed roof. It is well lighted by windows on every side and is spanned by a traveling crane suspended from the roof trusses. The walls are neatly finished and the floor laid in matched lumber, giving one of the most pleasant engine rooms in the copper district. The compressor is set on a solid concrete foundation.

The air pressure carried is 75 pounds, and air is led from the power house to the several shafts on the property. This compressor carries the major part of the load on the Mohawk property. There are, besides this large machine, two other Ingersoll-Sergeant Corliss compressors of an earlier pattern, located in another power house about a half mile distant. These latter machines have a combined capacity of about 3,000 cubic feet of free air per minute and are giving splendid service after years of operation, not only on the Mohawk, but on other work from which they were brought to the copper country. As is to be expected, the greater part of the air volume furnished by these compressors goes to rock drills in the mine, all of which are of Ingersoll-Sergeant and Rand manufacture. The illustration (No. 1585) shows the interior of the main power house and the air end of the large compressor.

Caisson Disease.

A difficulty to be contended with in foundations at great depth is the illness to which men working at high pressure are liable. This illness, in its milder manifestations, takes the form of swellings and tenderness, usually in the joints, and accompanied by severe pain. In fact, this last is such a very marked sympton of the malady that one of the names given it by the men, and which was always used at Newcastle, is the "pains." The longer the time under pressure and the higher the pressure the more severe are the symptoms. Foremen, lock-tenders, and others, who are usually under pressure for a short period at a time, rarely or never suffer except when the victims of a bad cold. In the more severe forms there is paralysis, and sometimes the results are fatal. An explanation of this disease, as a result of his researches and experimental work, was given on the continent by Paul Bert as far back as 1878, and more recently by Drs. Heller, Mager and Von Schrötter, and in our own country by Drs. Leonard Hill and Macleod. The explanation is this—quoting more particularly from Drs. Hill and Macleod—the blood gases increase, according to Dalton's law, under solution. On rapid de-compression gas bubbles escape, arresting circulation and causing pressure on nerves and tissue. The varying gravity of the symptoms is due to the varying seat of the air bubbles. Drs. Hill and Macleod have found that in animals caisson illness can be entirely prevented by slow de-compression, and that cases of illness of the greatest severity following on rapid de-compression from very high pressures can be cured by re-compression if applied soon enough. The explanation of this last is that on re-compression the bubbles go into solution. They therefore advocate slow de-compression, and recommend, as a result of their experiments, that, after a four-hour shift, in + 30 pounds, the period of de-compression should be 30 minutes to one hour. As the only cure they advocate immediate re-compression.

The beneficial effect of re-compression has long been known. At the Forth Bridge men suffering from "bends" were in the habit of spending their Saturday afternoons and Sundays in the working chamber; and at a tunnel under the Hudson River a medical lock, in which the

men might be re-compressed, was introduced by Mr. Moir, and was also used by him at the Blackwall Tunnel and by Mr. Davis at Newcastle. Dr. Snell, who was the medical officer appointed by the London County Council to look after the health of the men at the Blackwall Tunnel, in his book, "Compressed Air Illness," while accepting the gas theory of Drs. Hill and Macleod, is of opinion that it is in efficient ventilation that a remedy will be found. It was observed by him that an increase in the percentage of CO_2 was immediately followed by an increase in the number of cases of illness. In the discussion which followed the reading of a paper on the Blackwall Tunnel at the Institution of Civil Engineers, Mr. Moir stated that this had been his experience in tunnel work in America as well as at the Blackwall Tunnel. Dr. Snell is of opinion that slow de-compression, to be of use, must be longer than is practicable, and, therefore, recommends that de-compression should be only moderately slow, and that the percentage of CO_2 should be kept as low as possible. He is of opinion that ventilation at the rate of 12,000 cubic feet per man per minute is the ideal to aim at. The rule for the rate of de-compression at the Blackwall Tunnel was one minute for every 5 pounds above normal. The same rule was observed at Newcastle. As regards re-compression in the medical lock it must be remembered that this, to be most beneficial, must be immediate, and that subsequent de-compression must be extremely slow, say, thirty minutes to one hour from + 30 pounds, as recommended by Drs. Hill and Macleod. Drs. Heller, Mager and Von Schrötter emphasize the importance of the rate of de-compression being constant, and Drs. Hill and Macleod describe, in the account of one of their experiments, the fatal result of hastening de-compression for the last few pounds. An interesting paper has recently been published in the April number of the *Northumberland and Durham Medical Journal,* by Dr. Alfred Parker, dealing with the cases of illness at Newcastle. The subject has also been dealt with by Dr. Oliver, at the Medical Congress, at Oxford, in 1904, and by others.—G. W. M. Boycott, in *The Engineer* (Eng.).

Notes.

Air compressed by falling water will develop 4,500 horse-power to operate all branches of the Victoria Mine at Rockland, Ontonagon County, Michigan, when the new compressor is completed in a few days.—*Mining Reporter.*

The Worcester (Mass.) Compressed Air Housecleaning Company has been organized with the following officers: President, Dr. George E. Francis; vice-president, E. G. Connette; treasurer, J. W. Lester; directors, J. W. Lester, John E. Bradley, Francis E. Dewey and Edward G. Connette.

Compressed air employed as motive power in collieries at a distance from the shaft bottom is theoretically less efficient than electric transmission, on account of the thermo-dynamic loss of available energy. There is often a large leakage of air in long pipes. One of the chief advantages arising from the employment of compressed-air plants in coal mines is security from dangerous accidents.—*Engineering & Mining Journal.*

A joint meeting of the American Institute of Mining Engineers and of the English Iron and Steel Institute will be held in London, England, on July 23-29. The Lord Mayor of London has consented to act as chairman of the London reception committee and will give a conversazione in the Mansion House on the evening of July 24. A program of the visits and excursions to be made during the meeting will be issued when the arrangements are sufficiently matured.

An interesting test of the elevator air-cushions installed in the new Hall of Records, New York, by the Standard Safety Air-Cushion Co., recently took place in that building. A car weighing 3,500 pounds and containing two dozen eggs placed on the floor of the car was dropped from the eighth story, and after falling 125 feet with lightning speed, halted safely with only a few of the eggs cracked and none of them displaced enough to mar the pattern on the floor.

The treatment of minor open spaces in village and city, one of the most interesting problems of civic art to-day, will be

the subject of an article by Sylvester Baxter in the April *Century*. Among the illustrations, by Jules Guerin, of Mr. Baxter's text, will be pictures of Grand Circle, with the Columbus Monument, and Coenties Slip, New York, the first showing the effectiveness of formal treatment of an open space at the conjunction of important streets; the second the possibilities of securing a restful effect of roominess in a limited area.

THE chief cause of knocking out a machine and of breaking, bending and blunting drills is carelessness and the lack of supervision while starting holes. It is also contended that in actual practice nearly 40 per cent. more work can be done in a given time with the air pressure in underground machine boring in ground of the average hardness found in the Transvaal at 80 pounds instead of at 60 pounds. In West Australia 100 pounds pressure has been kept on the receiver when working in hard quartz. A mistaken desire for economy may induce the miners or the pipe repairer to use worn-out piping and hose for connection, which of course leads to frequent stoppage and to a more or less constant loss of air by leakage.—*The Mining World.*

THE general use of compressed air in railroad boiler shops, it is stated, which had largely aided in advancing boiler-shop practice to the front rank in the railway mechanical departments, is being extended in some shops to include the cleaning of crown bars and crown sheets with a sand blast. It is claimed to do much more satisfactory work than the old way with the hammer and chisel. In a shop where the sand blast is now being used, it formerly took a 17½-cent man ten hours to clean a dozen bars—$1.75 for the lot. With a sand blast a bar is cleaned in 20 to 30 minutes, or in about half the time it took in the old way, and the blast makes a cleaner job. This same shop is said to use the blast for crown-sheet cleaning with satisfactory results.—*Boiler Maker.*

THE publication of a description of a unique engine which has just been built for the South Norwalk Municipal Electric Company has been the basis of much discussion in mechanical circles throughout the State. This new engine involves a new use of a very old and well known principle of physics, viz., that mechanical energy may be transformed into thermic, or heat, energy by compression of the atmosphere. Anyone who has ever used a hand-power air-pump is acquainted with the fact that its barrel quickly becomes hot. It is often said that this is produced by the friction of the pump; but friction has very little to do with it. The heat is produced by the compression of the air within the tube.

The new engine is equipped with an air compressor which compresses the air into a tank at a pressure of 75 atmospheres, or 7' times the pressure of the atmosphere under normal conditions—about 14.72 pounds to the square inch. This is used to give the first stroke of the engine. On the return stroke of the engine the compressor is given back practically all the air lost in the first stroke. This return compresses the air sufficiently to drive from it enough heat to raise the temperature of the cylinder to a temperature of nearly 700 degrees, Fahrenheit. The third stroke is produced by the explosion of crude oil injected into the hot cylinder.

The chief interest in the new engine from a scientific point of view is the method of converting mechanical, or dynamical, energy into heat energy. Theoretically, by the use of this method of air compression practicallv all attendant losses are avoided, and, therefore, the method promises to come into general use on account of its economy. And it will be interesting to those mechanical geniuses of Connecticut to watch the result of this new experiment.—*Ex.*

THE average depth of a tube well in London is 400 to 500 feet, and the yield obtained varies from 1,000 to 35,000 gallons per hour from single-bore holes. Two artesian wells have recently been sunk at the Prince of Wales's Road Baths, Kentish Town, for the St. Pancras Borough Council, which give a supply of 30,000 gallons per hour. On account of the first of these wells having been reported as yielding no supply, it was on the eve of being abandoned when Messrs. C. Isler & Co. were consulted, and proved a supply of over 15,000 gallons per hour by means of their system of pumping by compressed air. These satisfactory results induced the council to put down an addi-

tional well, which is carried to a depth of 480 feet, and to permanently install air-lift pumping machinery. There are, of course, many wells in "inner" London, but this is one of the most favorable sites, there being no others to our knowledge capable of yielding this amount of water. The water is drawn through the chalk, and, being of the greatest purity, is suitable for any purpose, domestic or manufacturing. The same firm has carried out many interesting works of the kind in London, and one at the Metropolitan Electric Supply Company's station at Acton Lane, Willesden Junction, is specially worthy of mention. An artesian well was sunk to a depth of 1,000 feet, chalk being reached at 340 feet from the surface. No supply of water, however, could be obtained. It was then resolved that part of the bore pipes which lined through the Woolwich and Reading beds (sand beds) should be destroyed, and this was accomplished by blasting with specially made gelatine cartridges at a depth of 365 feet. A compressed air lift plant was then put into action, and, by employing other special means and appliances, a supply of 10,600 gallons per hour was obtained.—*London Telegraph.*

It's still cool in the subway for the same reason that it's cool in the streets. During the stinging cold days of winter the comparative warmth of the bore was a blessed comfort to the chilly New Yorker. Little thought then was taken of whether or not the air was vitiated. It was warm, that was enough. But the approach of warmer weather has brought to the fore again the problem of ventilation.

Practically nothing has been done to insure purer air in the subway. The pocket-size electric fans that were installed on tiny ledges at the express stations last summer lived their butterfly life and were either removed or left to rust into innocuous desuetude. The two or three large fly-wheel sort of fan-pumps are covered with dust and look as lonesome, useless and out of date as a French Panama dredge.

These are sights to set the average New Yorker thinking. Surprise has been expressed that the summer will in all probability be allowed to come without any preparation for the ventilation of the underground railroad.

"To begin to install some system under the stress of an aroused and sweating public opinion would be not only farcical, but totally ineffectual," said a well-known engineer to-day. "It seems simply remarkable that New Yorkers never think of their necessities until they're in trouble. All winter they will calmly ride up and down that evil-smelling tunnel without a thought of any future discomfort other than a possible inhalation of steel particles. But as soon as it gets hot and the bore is pretty nearly converted into a huge main for perspiration, they get on their hind legs and kick so almighty hard that the company makes some sort of display of interest, and puts in a teeny-tiny electric fan or two. And I don't blame the company very much, either. I give it credit for knowing human nature."

The subject of subway ventilation is a large one and a puzzler to engineers. Any number of schemes have been suggested, ranging from the electric fan to flushing the tunnel bore with compressed air, much as a pipe is flushed with water. A big difficulty to be overcome is getting the necessary pure air into the passage with as little machinery as possible and without erecting obstructions in the street above. Recently a plan has been talked of that is extremely interesting to transportation men and may go far toward solving the subway problem.

It is nothing less than supplying the subway with highly compressed air, to be gathered into a reservoir at a central point and distributed through pipes to different parts of the bore, as gas is now distributed to given points in a given locality.

Compressed air has only within the past few months been made into a commercial commodity. It is now being sold to consumers for so much a cubic foot, in exactly the same way as gas is sold. George Westinghouse, head of the Westinghouse Company, early in the year made this possible by putting on the market an "air meter," which measures air—to use the same analogy—exactly as gas is measured. The capacity of a meter is 50,000 cubic feet an hour. What new fields of enterprise this invention opens up no one can as yet foretell. But it is expected that compressed air factories—if that term may be used—will shortly be established in this and other large cities for the peddling out of air. It may be that the day of the compressed-air carpet-cleaning

wagon at the curb is pretty nearly over. The uses of compressed air are many, so that promoters have a large field to work in.

So far the extent of distribution has been no greater than a radius of ten miles. In Belleville, Utah, near Salt Lake City, there is a central compressing plant that supplies air in pipes to the Pittsburg Mining Company, the Fortuna Mining Company, the Ohio Copper Company, the United States Mining Company, and the Honerine Tunnel & Milling Company, the last of which owns and sells the condensed atmosphere to the other four concerns. The air is used principally for supplying the miners. Without it the mines would be almost useless.

It is believed that with the extension of the system many mines that have been abandoned because of great depth will be workable again. So it is that a sort of mining renascence is being looked forward to in certain districts of the West.

The invention of the meter was what made this system of central supply of air feasible and a good business proposition. Every customer—and there may be any number of customers—may pay only for the air he uses. He and his fellow consumers would not be under the necessity of constructing and maintaining their own individual compressing plant, usually an item of much expense.

Should the subway adopt some such method of air distribution as has been mentioned, it would be possible to cool the air as needed, so that some time in the future passengers may get to look upon the subway as something to be enjoyed, rather than a means of quick transportation under trying conditions.—*New York Evening Sun.*

For the conveyance of water, gas, steam or compressed air pipes are made of various materials. In all cases they are subjected to internal pressure, but sometimes the external pressure is of more importance in determining the thickness of metal, for instance in the case of water mains and gas pipes laid below the surface of the streets. These may be subject to the pressure produced by the traffic, or they may be liable to bending strains due to the settlement of the supporting earth in some places. For determining the thickness of metal for a boiler or large pipe subject to internal pressure we employ the following rule: The greatest safe pressure per square inch, multiplied by the diameter in inches, is equal to twice the thickness of metal multiplied by the safe working tensile stress of the material per square inch. Or, pressure+Diameter=2 Thickness× Safe Stress.

This rule makes no allowance for the external and transverse stress mentioned above, nor is any allowance made for the difficulties of casting a pipe of very thin material, nor for the prosity of the cast metal. Thus it is necessary in practice to make these pipes considerably thicker than those given by the above rule, in order to be secure from breakage, or failure, from all causes. The following numerical example will serve to make this matter more clear.

Example.—It is required to find the thickness of cast-iron pipes one foot in diameter, for water main to resist the pressure due to a head of water of 250 feet.

Note.—We may assume the strength of cast iron suitable for this purpose to be eight tons per square inch, and that a head of water equal to 2,304 feet produces a pressure of one pound per square inch.

Now applying the above rule, and taking the safe stress at one-fourth the breaking stress,

Pressure + Diameter = 2 Thickness × Safe Stress

$$\textbf{Thickness} = \frac{\textbf{Pressure} \times \textbf{Diameter}}{2 \times \textbf{Safe Stress}}$$

$$\textbf{Thickness} = \frac{\dfrac{250}{2.304} \times 12''}{2 \times \dfrac{8 \times 2240}{4}}$$

$$\textbf{Thickness} = \frac{250 \times 12}{2 \times 2 \times 2240 \times 2.304}$$

$$\textbf{Thickness} = \frac{25}{224 \times .768} = .145 \text{ inch}$$

From the above rule the thickness only requires to be a little more than one-eighth inch, but it should be made half an inch, or not less than three-eighths of an inch in order to guard against the risks enumerated above. By using the above rule and taking the safe stress at one-

tenth or one-twelfth the breaking strength, good results will be obtained.

Example.—Find the thickness of cast-iron pipes four inches in diameter, suitable for resisting a water pressure of 700 pounds per square inch.

$$\text{Thickness} = \frac{\text{Pressure} \times \text{Diameter}}{2 \times \text{Safe Stress}}$$

$$\text{Thickness} = \frac{700 \times 4}{\frac{2 \times 8 \times 2240}{10}}$$

$$\text{Thickness} = \frac{700 \times 4 \times 10}{2 \times 8 \times 2240} = \frac{175}{224}$$

Thickness=.78 inch=25-32 of an inch.

When the pipes are made of wrought iron, steel or copper, etc., they are not made so thick as cast-iron ones; chiefly because they are not subjected to the before-mentioned external stresses. The material is of better quality and is not so liable to irregularities of thickness, etc., during the process of making.—*American Cotton Manufacturer.*

INDEX.

U.S. PATENTS GRANTED FEB., 1906.

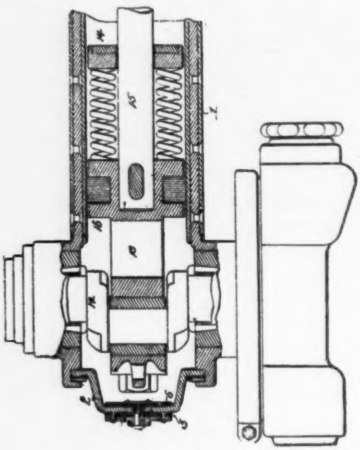
Specially prepared for COMPRESSED AIR.

811,687. AUTOMATIC EMERGENCY AIR-BRAKE-OPERATING DEVICE FOR RAILWAYS. John P. Birmingham, Lexington, Va., assignor to Robert Catlett and Robert Athelstan Marr, Lexington, Va.; William George Mathews, Cliftonforge, Va., and James Easley Edmunds, Don Peters Halsey, and James William Gerow, Lynchburg, Va. Filed July 31, 1905. Serial No. 272,025.

811,690. PNEUMATIC LIFTING MEANS FOR GRAIN-DOORS. Tilghman E. Branson, Belleplaine, Kans., assignor of one-third to Harry Hatfield and one-third to W. S. Foster, Belleplaine, Kans. Filed Mar. 23, 1905. Serial No. 251,668.

811,732. ARMOR FOR PNEUMATIC TIRES. Alanson A. Moore, Detroit, Mich., assignor of one-half to Frank H. Bessenger, Detroit, Mich. Filed Feb. 21, 1905. Serial No. 246,767.

811,685. ROCK DRILL. Thomas E. Adams, Cleveland, Ohio. Filed May 27, 1905. Serial No. 262,619.



In a device of the character described, the combination with means for inducing an air-current, of valve mechanism for controlling the direction of said air-current to control the direction of feed of lubricant in the device.

811,723. PNEUMATIC SULKY. Samuel E. Jerald, Waterloo, Iowa. Filed Apr. 26, 1905. Serial No. 257,427.

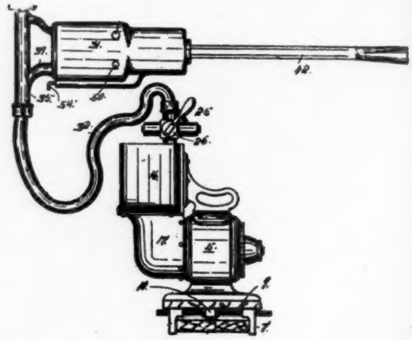
811,736. PNEUMATIC STRAW-STACKER. Joseph W. Nethery, Indianapolis, Ind., assignor to The Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed June 26, 1905. Serial No. 267,025.

811,765. AIR-BRAKE SYSTEM AND AUTOMATIC VALVE. Fred B. Corey, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Sept. 16, 1904. Serial No. 224,651.

811,863. AIR-BRAKE. Ernest H. Miller and Charles V. Rote, Lancaster, Pa., assignors of one-third to John W. Holman, Lancaster, Pa. Filed July 21, 1904. Serial No. 217,476.

811,915. PNEUMATIC-TUBE CASH-CARRIER. Daniel S. Hager, Toledo, Ohio. Filed Nov. 9, 1905. Serial No. 286,450.

811,791. MEANS FOR OPERATING DRILLS. Olin S. Proctor, Denver, Colo. Filed Apr. 29, 1905. Serial No. 258,101.



A rock-drill of the class described, including a cylinder, a piston, and means for introducing motive fluid to the cylinder, of a by-pass leading from the drill-cylinder to a point forward of the piston for delivering fluid to the drill-hole, and a check-valve located in said by-pass and adapted to allow fluid to pass therethrough to the drill-hole but arranged to prevent the return of the rock cuttings into the cylinder.

812,151. FLUID-OPERATED ENGINE. Bruno V. Nordberg, Milwaukee, Wis. Original application filed Sept. 18, 1903. Serial No. 173,691. Divided and this application filed Nov. 29, 1904. Serial No. 234,757.

In an engine adapted to deliver a blow, the combination of two cylinders; a piston working in each of said cylinders; a piston-rod common to said pistons; means for admitting steam simultaneously and at the same pressure to the upper face of each of said pistons; and means for admitting steam to the under face of one of said pistons while steam is exhausted from the opposite face of each of said pistons.

812,162. PNEUMATIC TUBE FOR STORE SERVICE. Thomas Bemis, Indianapolis, Ind. Filed Dec. 18, 1905. Serial No. 292,330.

812,228. FLUID-PRESSURE METAL-WORKING MACHINE. Casimir von Philp, Bethlehem, Pa., assignor to The Bethlehem Steel Company, South Bethlehem, Pa., a Corporation of Pennslyvania. Filed Aug. 24, 1904. Serial No. 222,014.

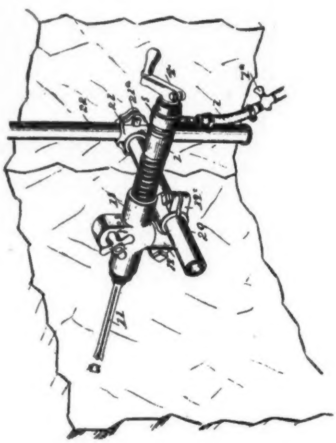
In a fluid-pressure metal-working machine, the combination with a platen, of a fluid-pressure

cylinder and plunger mounted in said platen, a bed-plate, a plurality of jacks upon the bed-plate for supporting the work, and means for moving said jacks with relation to said platen, for the purpose set forth.

812,271. PNEUMATIC - DESPATCH - TUBE SYSTEM. John S. Jacques, Dorchester, Mass. Filed May 24, 1905. Serial No. 261,963.

812,375. ROCK-DRILL. Clark J. Smith, Ottumwa, Iowa, assignor to The Hardsocg Wonder Drill Company, Ottumwa, Iowa. Filed Aug. 7, 1905. Serial No. 273,125.

In an apparatus of the class described, a supporting-casing, a drilling mechanism supported therein and feedable therethrough, means co-operatively connecting the supporting-casing and the drilling mechanism to permit the drilling mechanism being fed forward at each forward impulse of the drill-hammer, and means whereby said drilling mechanism can be bodily withdrawn from said supporting-casing, substantially as shown and described.



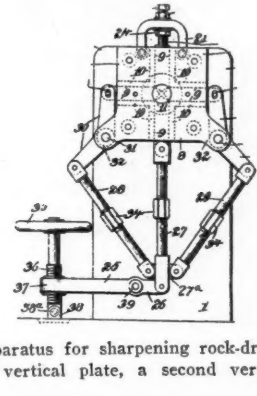
An apparatus of the class described, comprising drilling mechanism consisting of an elongated tubular casing having an external thread, a tubular hammer-barrel fitted within said casing, a drill-chuck within said hammer-barrel at its forward end, a closure-plug within said hammer-barrel at its rearward end, inlet-apertures connecting with the interior of the hammer-barrel and the interior of the drill-casing, exhaust-ports for the hammer-barrel, a reciprocating hammer within the hammer-barrel, means for admitting compressed air into the drill-casing, a handle member secured to the drill-casing whereby the same can be turned on its longitudinal axis, a tubular supporting-casing having a bore for receiving the drill-casing, a worm-gear mounted in said supporting-casing and adapted to mesh with the threads on the drill-casing, a hand-wheel for turning the worm-gear, said worm-gear and said drill-casing being arranged to allow the drill-casing to be automatically fed forward by the forward movements of the hammer, while simultaneously permitting the drill-casing to be turned on its longitudinal axis by means of the handle, and means for mounting said supporting-casing to permit adjustment of the drilling mechanism with the longitudinal axis of the drill-casing at any angle substantially as shown and described.

812,423. MEANS TO REPLENISH THE AIR-CHAMBERS OF PUMPS WITH AIR. Henry T. Hazard, Los Angeles, Cal., assignor of one-half to Albert Hoberecht, Ensada, Mexico. Filed Oct. 5, 1904. Serial No. 227,278.

Means to replenish the air-chamber of a pump with air, comprising a main air-chamber and a supplementary chamber below the same, a partition therebetween, a port in said partition and a port in the bottom of the supplementary chamber and valvular means to alternately open and close said ports.

812,451. AIR-VALVE. William J. Rice, Mason City, Iowa. Filed Nov. 7, 1904. Renewed July 22, 1905. Serial No. 270,897.

812,570. APPARATUS FOR SHARPENING ROCK-DRILLING MACHINE BITS. Joseph A. G. Kirsten, Randfontein, Transvaal. Filed Mar. 15, 1905. Serial No. 250,151.



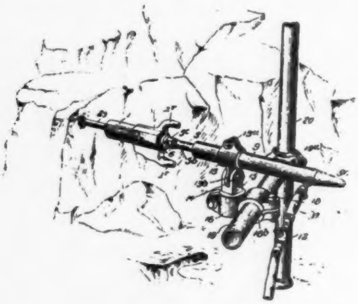
In apparatus for sharpening rock-drilling bits, a main vertical plate, a second vertical plate

fixed thereto and having a central aperture and vertical and horizontal guideways radiating from said aperture, die-carriers in said guideways, dies attached to said carriers, a device for adjustably supporting the top vertical die, levers pivoted to the second plate and connected to the horizontal die-carriers, a lever pivoted to the main plate and yieldingly connected with the bottom vertical die-carrier and with the levers operating the horizontal die-carriers, and means for operating the lever pivoted to the main plate.

812,697. AIR-BRAKE APPARATUS. Augustus A. St. Clair, Indianapolis, Ind. Filed Aug. 12, 1905. Serial No. 273,871.

812,752. DISTRIBUTING-VALVE FOR AIR-BRAKES. Georg Knorr, Britz, near Berlin, Germany. Filed July 11, 1904. Serial No. 216,171.

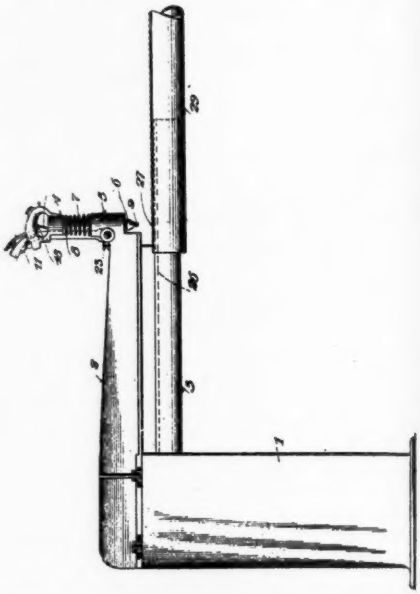
812,774. ROCK-DRILL. Clark J. Smith, Ottumwa, Iowa, assignor to The Hardsocg Wonder Drill Company, Ottumwa, Iowa. Original application filed Aug. 12, 1905, Serial No. 273,930. Divided and this application filed Sept. 2, 1905. Serial No. 276,876.



In an apparatus of the class described, the combination with a drill-casing and a drill carried thereby, a clamp for receiving said drill-casing, said clamp including means whereby the drill-casing can be swung clear of the drill and back again without changing the alinement of the drill-casing substantially as shown and described.

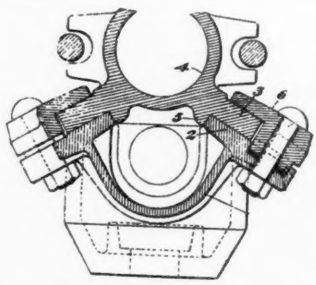
812,792. PNEUMATIC - DESPATCH - TUBE SYSTEM. John S. Jacques, Dorchester, Mass. Original application filed May 24, 1905, Serial No. 261,963. Divided and this application filed Dec. 23, 1905. Serial No. 293,092.

812,787. PNEUMATIC RIVETING-MACHINE. John R. French, Los Angeles, Cal. Filed Feb. 1, 1904. Serial No. 191,443.



In a pneumatic riveting machine, a support, a riveter movably mounted therein and provided with valve mechanism, means for moving the riveter, and a connector from the valve mechanism to said means so arranged as to be operable to control the valve at any position of the riveter.

813,041. ROCK-DRILL. David C. Demarest, Angels Camp, Cal. Filed May 4, 1905. Serial No. 258,845.



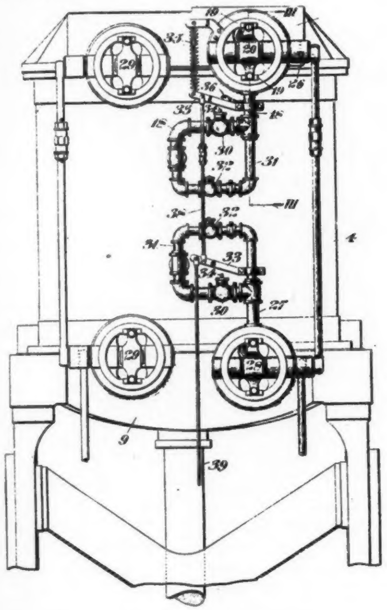
In a rock-drilling machine the combination of a shell and a cylinder supported thereon, one of

said parts having lugs and the other part having seats for said lugs, and means to clamp the cylinder to the shell, said means including bolts passing through the caps and shell, said shell having counterbores, and said caps having bosses fitting said counterbores.

812,883. DOOR-OPERATED AIR-PUMP FOR ATOMIZERS. William H. Rose, Baltimore, Md. Filed Oct. 30, 1905. Serial No. 285,060.

812,989. POWER-BRAKE MECHANISM. Curtis B. Goode, Boston, Mass. Filed Jan. 4, 1905. Renewed Nov. 11, 1905. Serial No. 286,836.

813,064. CONTROLLING MECHANISM FOR BLOWING-ENGINES. Johnson V. Symons, Johnstown, Pa. Filed May 18, 1905. Serial No. 260,935.



In a blowing-engine, the combination with the air-cylinder and the main shaft, of an outlet-valve for the air-cylinder, an actuating-cylinder for said valve, a passage-way connecting said actuating-cylinder with the air-cylinder, a controlling-valve in said passage-way, a by-pass for said controlling-valve, a check-valve in said by-pass, a lever for closing said controlling-valve; a ratchet-clutch on the main shaft operative only when the engine is run backward, a rock-shaft connected with said clutch, a rocker-arm on said rock-shaft, a friction-clutch interposed between said rocker-arm and said rock-shaft, a connection between said rocker-arm and said lever and means for returning said lever and its operating mechanism to their normal position when inoperative.

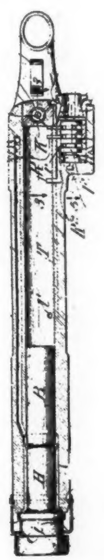
813,073. PNEUMATIC GRAIN-ELEVATOR. William C. Allen, Gurley, Ala. Filed May 10, 1905. Serial No. 259,744.

813,075. GENERATOR OF FLUID-PRESSURE. Adrien Baudin, Paris, France. Filed Aug. 5, 1903. Serial No. 168,325.

A fluid-pressure generator comprising a chamber containing a quantity of aqueous material, a pump for drawing air through said material, a chamber into which the cooled and moistened air is delivered, and means for heating said last-named chamber.

813,090. AIR-BRAKE MECHANISM. Alva L. Goodknight, Council Bluffs, Iowa. Filed Sept. 6, 1905. Serial No. 277,228.

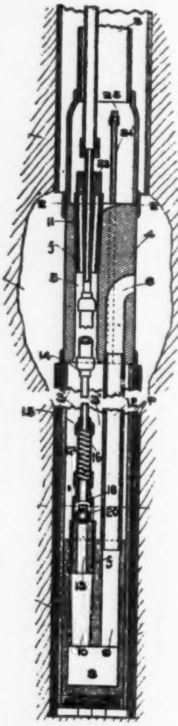
813,109. PNEUMATIC HAMMER. Reinhold A. Norling, Aurora, Ill., assignor to Aurora Automatic Machinery Company, Aurora, Ill., a Corporation of Illinois. Filed Feb. 17, 1905. Serial No. 246,146.



The combination of a cylinder having an integral handle on its inner end and a bore which extends through its said inner end, a plunger in said cylinder, a controlling-valve casing integral with and extending laterally from the inner end of the cylinder and having a bore

which is closed at one end by the integral, outer end wall of the casing and opens at its other end through the inner end of the casing, a valve-piston in the said valve-casing having its central axis parallel with the cylinder, and separate closures for the inner end of the bore of the cylinder and for the bore of the valve-casing.

813,322. DEVICE FOR RAISING LIQUIDS FROM WELLS. William Richards, Mayburg, Pa. Filed Feb. 3, 1904. Serial No. 191,841.



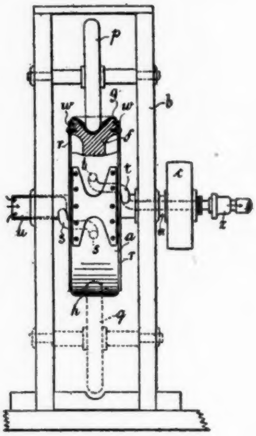
In an improved device for raising liquids from wells, a reservoir located below the producing strata, a bridge located at the upper end of said reservoir, a valve located in said bridge, there being an air-passage and an oil-passage formed within the body of said valve.

813,305. SUPPLY AND EXHAUST VALVE MECHANISM FOR MOTORS. Wilber H. Johnson, Cumberland, Md. Filed July 5, 1902. Serial No. 114,436.

In a motor, the combination of a motor, a piston operating therein, a fluid-supply pipe, a controlling-valve in said pipe, reciprocating means governed by the piston for periodically operating said valve, an exhaust-valve in the supply-pipe controlling the exhaust of spent fluid from the motor to the atmosphere, and means of which the first-mentioned means form a part for operating the exhaust-valve alternately with the said controlling-valve.

813,390. AIR-BRAKE COUPLING. Heraclitus H. Sartain, Burroughs Cove, Tenn. Filed June 17, 1903. Serial No. 161,881.

813,443. COMPRESSOR. Hans Mikorey, Schoneberg, near Berlin, Germany, assignor to The Firm of W. Graaff & Company Gesellschaft mit Beschrankter Haftung, Berlin, Germany. Filed May 10, 1905. Serial No. 259,797.



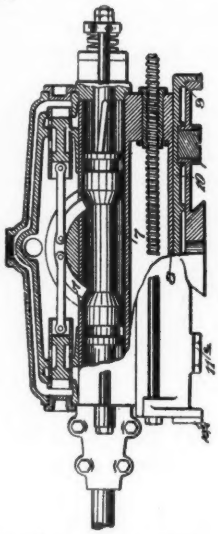
A compressor comprising a wheel having a groove on its periphery, a membrane formed of rubber stretched across said groove so as to form an annular chamber, means for holding said membrane at one point permanently pressed against the bottom of the chamber, an inlet-pipe entering said chamber on one side of said means, an outlet-pipe on the other side thereof and a roller of less thickness than the wheel engaging the membrane so as to force it against the bottom of the groove.

813,747. AUTOMATIC AIR-BRAKE COUPLING. Arthur H. Skillings, Brooklyn, N. Y. Filed Dec. 15, 1904. Serial No. 236,924.

813,636. PNEUMATIC - DESPATCH - TUBE APPARATUS. Edmond A. Fordyce, Boston, Mass., assignor to Lamson Consolidated Store Service Company, Newark, N. J., a Corporation of New Jersey. Filed Mar. 24, 1905. Serial No. 251,770.

813,691. BRAKE AND TRACK-SANDING MECHANISM. Murry A. De France, Newark, Ohio, assignor of one-fourth to Albert H. Sisson, one-fourth to Charles E. Krebs, and one-fourth to W. Bernard Wingerter, Newark, Ohio. Filed Sept. 7, 1905. Serial No. 277,378.

813,828. ROCK-DRILL. Edward A. Rix, San Francisco, Cal. Filed Aug. 16, 1905. Serial No. 274,487.

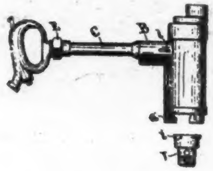


The combination in a rock-drill, of a cylinder, having a slide fixed to and projecting from its bottom, a shell within which said slide is movable, the bottom of said slide and the bottom of the guide being spaced from each other, and means operable in said space between said bottoms and adjustable in one direction to compensate for wear between the bottom and also the sides of said guide.

813,900. PROTECTING DEVICE FOR PNEUMATIC TIRES. Emile Lapisse, Elbeuf, France. Filed Sept. 2, 1905. Serial No. 276,828.

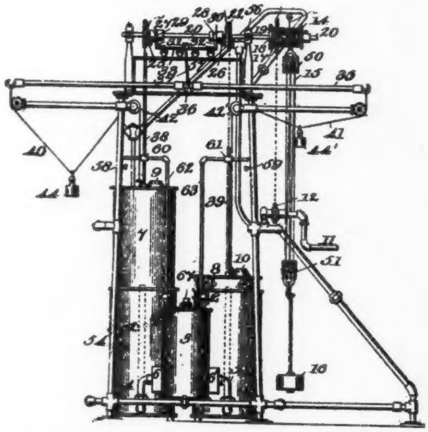
813,934. PROTECTIVE COVER FOR PNEUMATIC TIRES. Josef Albers, Aix-la-Chapelle, Germany. Filed Apr. 7, 1905. Serial No. 254,415.

813,921. PNEUMATIC DOLLY. James A. Shepard, Montour Falls, N. Y., assignor to The General Pneumatic Tool Company, Montour Falls, N. Y. Filed May 6, 1903. Serial No. 155,866.



In a dolly, the combination of a barrel, a piston projecting therefrom, a die set eccentrically upon the end of the piston, a handle projecting from one side of the barrel, a longitudinal slot on the piston, a guiding member in the barrel in engagement therewith, whereby the piston is held from rotation with freedom to reciprocate and the die is held in fixed relation to the handle, and means for admitting fluid under pressure behind the piston.

813,982. SELF-REGULATING AIR-PUMP. Maximilian Loewenstein, Brussels, Belgium, assignor of two-thirds to Jonas Stork, Brussels, Belgium, and Maurice Kind, New York, N. Y. Filed Apr. 14, 1905. Serial No. 255,617.



In a self-regulating air-pump, the combination of a series of bells, means for lifting said bells alternately and automatically, and connections whereby the fall of one bell immediately causes it to be lifted and at the same time releases another bell, substantially as described.

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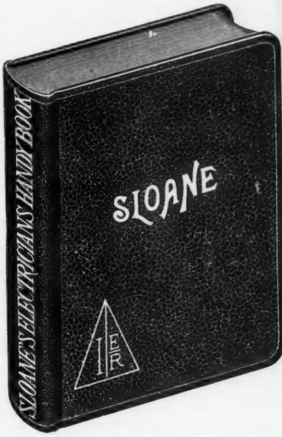

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